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ASTM BULLETIN

Published by
AMERICAN SOCIETY for
TESTING MATERIALS

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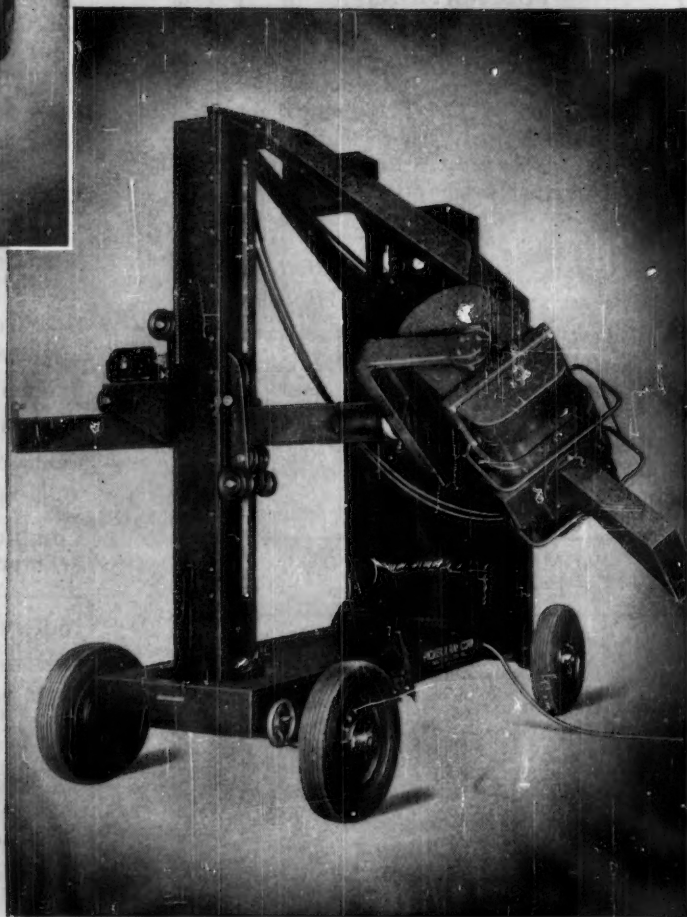
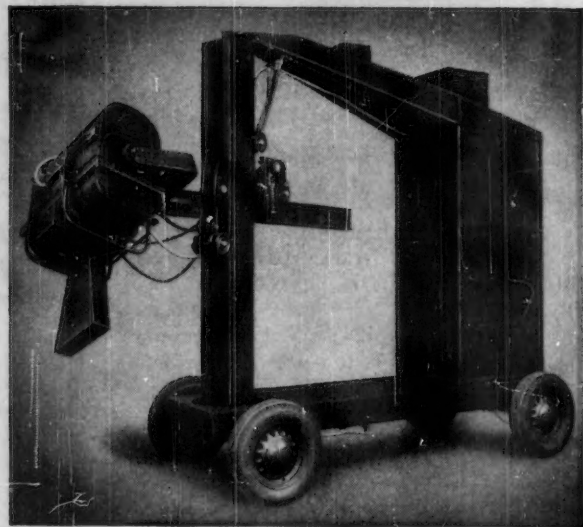
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ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering and Standardization of Specifications and Methods of Testing"

TELEPHONE—PENNypacker 3545

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Number 123

August 1943

A.S.T.M. Work Advanced at Annual Meeting

Heavy Attendance, Good Technical Sessions, with Committee Meetings Probable High Point

WITH THE TOTAL registration for the four days of the 1943 Annual Meeting in Pittsburgh, June 28-July 1, inclusive, reaching 1452, an interesting series of 15 technical sessions, including an outstanding Edgar Marburg Lecture and a most interesting general session, with two of Pittsburgh's leading industrialists present, plus a notable group of technical committee meetings, totaling 245, the meeting as a whole ranks among the best ever held by the Society. The real significance and value of any A.S.T.M. annual meeting is made up of a combination of factors, and the high spot for one individual may be entirely different from that of another. Yet viewed broadly on the basis of standardization work accomplished, research activities reviewed and planned, and the general estimates of the worth of the technical papers and reports presented, the meeting from the standpoint of the materials engineer was extremely significant in many aspects.

Attendance is just one indication of interest, and the total of 1452, the third highest in the Society's history, is indicative of the desires of industry to continue actively in the work. Only the 1937 New York meeting (registration 1523) and the 1941 Chicago meeting (registration 1553) exceeded this year's total. Of those present 757 were members; 323 registered as committee members, that is, not personal members or the official representatives of company memberships; and 372 were visitors. It should be remembered, too, that exhibits of testing apparatus and related equipment were held at both the New York and Chicago meetings whereas these were lacking in the present instance. In the interest of war production it was deemed best to cancel the 1943 exhibit.

COMMITTEE MEETINGS FEATURE

One phase of the four-day meeting noted particularly by a number of Society officers and others was the large number of well-attended and interesting committee meetings. Beginning Monday morning, and extending through Thursday, there were about 245 of these arranged by standing technical committees and their subgroups, this figure also including a few meetings of groups sponsored by other societies and trade associations. Even though in an advance scheduling of committee rooms it

was thought ample provision had been made for the estimated number of men expected to be present, there were quite a number of overflow meetings. The results of the actions and discussions at these meetings will, of course, be apparent during the coming year when many of the programs are under way. A number of additional recommendations not preprinted were referred to the Annual Meeting as the *Summary of Proceedings* will indicate, which *Summary* will be distributed to each member early in August. An article published later in this BULLETIN on standardization work also is indicative of committee activity. The amount of new work planned, particularly on new specifications and tests but also on numerous research projects, certainly indicates the demand by industry and Government for authoritative information and data on materials.

TECHNICAL SESSIONS

Each of the 15 technical sessions was well attended with interest maintained throughout. Detailed reference is made later to the so-called general session and Edgar Marburg Lecture session. Two sessions were devoted to the Symposium on Soil Test Methods; and Water, and the Symposium on Identification of Water-Formed Deposits, Scales, and Corrosion Products by Physico-chemical Methods served as the subject of another constructive session. The Symposium on Hardness Testing was still another. There were four sessions in the metals fields, notably one on corrosion and electrodeposited coatings another on effect of temperature and fatigue, and two others on non-ferrous metals and on iron and steel. Cementitious materials and concrete were covered in the two closing sessions with a series of interesting papers and reports. Petroleum products and asphalt comprised the fifth session, and the seventh and twelfth included a miscellaneous number of subjects with a particularly good attendance at the twelfth in which rubber and plastics were the principal topics. Features of some sessions are outlined below.

GENERAL SESSION—PRESIDENT'S ADDRESS; DUDLEY MEDAL AWARDED; ADDRESSES BY MESSRS. PHELPS AND BELL

There was a capacity crowd at the general session Wednesday evening at which H. J. Ball presented his



New President
Dean Harvey

retiring President's Address; the Dudley Medal was awarded to Walter Bonsack; and two interesting addresses were given by Frank B. Bell, District Chief, Pittsburgh Ordnance District, U. S. Army, and Andrew H. Phelps, Vice-President in Charge of Purchases and Traffic, Westinghouse Electric and Manufacturing Co. Excerpts from the remarks of Messrs. Phelps and Bell appear on the succeeding pages. They received a warm reception from the large crowd present.

At this general session the new officers were introduced, Dean Harvey the new President, and J. R. Townsend, the new Vice-President, making appropriate remarks, and pledging their whole-hearted cooperation during the year. At this session recognition was also given to the list of 18 personal members and companies who earned the 40-year award, having been continuously affiliated with the Society since 1903. On a succeeding page of the BULLETIN are given data on the new officers of the Society and following this a list of the new 40-year members.

PRESIDENT'S MESSAGE

In discussing the work in which he has been so active, namely, the textile field, as covered by Committee D-13 on Textile Materials, President Ball indicated it was typical of many other A.S.T.M. projects in both the metals and nonmetals fields, but pointed out that it covered a very extensive group of materials. Copies of the complete address are being printed and one will be sent without charge to any one who sends a request to A.S.T.M. Headquarters. Professor Ball concludes:

"The quality of the standards which the textile industry has prepared for itself, coupled with the prestige and the sensible requirements of the A.S.T.M., has placed them in an authoritative position in the industry. This position must not be impaired one iota. Those who put faith in the integrity and scientific character of our work must not have that confidence shaken or violated. To see that the standards shall be reliable, unbiased, practical, technically correct, and comprehensive must be the standard upon which the eyes of its officers and committee chairmen are constantly focused. Under such conditions the textile industry will continue to accept the leadership of the A.S.T.M. in the standardization field, and its influence will become even more widespread and effective as the years roll by."

EIGHTEENTH EDGAR MARBURG LECTURE ON "WOOD"

One of the high lights of the meeting and an outstanding technical contribution was the 1943 Edgar Marburg Lec-

ture, the eighteenth in the series, presented this year by L. J. Markwardt, Chief, Division of Timber Mechanics, Forest Products Laboratory, Madison, Wis. There were more than 450 in the lecture hall. Although Mr. Markwardt was covering a very broad subject "Wood as an Engineering Material," he did so in an excellent manner, at the same time confining his remarks to about one hour, during which time he demonstrated a number of interesting timber products. The published lecture will be a most extensive and interesting contribution and will provide much more detailed information and data than could possibly have been covered in the limited lecture time.

Mr. Markwardt pointed out that the annual lumber production, about 32 billion board feet, would provide a landing mat 1 in. thick and 250 ft. wide to go completely around the world at the equator. With the industry employing recently over one million persons, it ranked sixth in value of product, producing material valued at \$4,410,000,000. Referring to the fact that prejudice and rule-of-thumb had been largely dispelled by intensive research in recent years, there is, nevertheless, some ground for the statement, "It is not the things we don't know that do us the most harm, but the ones we do know that are not so." He detailed some of the remarkable developments in mechanical seasoning, and then gave those present a quick picture of some of the other important advances. The closing portion of his remarks relating to the future of wood was prefaced by Lowell's ditty,

"My gran' ther's rule was safer'n 't is to crow;
"Don't never prophesy—unless ye know."

He listed several broad lines of marked advancement during the last decade's renaissance in wood:

1. Improvement in joints and fastenings, usually the critical feature of structural timber design.
2. Better structural grades, affording more precise strength evaluation and more uniform quality.
3. Improvements in glue and gluing technique, including the development of synthetic resins that afford essentially waterproof joints.
4. Extensive developments in plywood production, making available a large variety of constructions, with moisture-resistant properties, if desired.
5. Advent of chemical seasoning methods, which not only result in quicker drying, but in the practical elimination of drying defects.
6. Increased facilities for wood preservation, affording opportunity for increased life and serviceability and reduced maintenance costs.



New Vice-President,
J. R. Townsend



Secretary-Treasurer C. L. Warwick; E. W. Upham, Chrysler Corp. (Executive Committee Member); President H. J. Ball, Lowell Textile Institute • A. R. Ellis, President, Pittsburgh Testing Laboratory, Chairman of Pittsburgh Committee on Arrangements • Guest Speakers at the General Session: A. H. Phelps, Westinghouse Electric and Manufacturing Co.; F. B. Bell, Pittsburgh Ordnance District.

7. Composite constructions, using wood with other materials, and employing to best advantage the salient properties of each.

8. Improved wood, plastics, and paper-base laminates, involving chemical conversion or resin-impregnation, offering a variety of products that are finding many new uses.

9. A wide variety of fiberboards with properties designed to meet particular requirements.

10. New developments in molding and laminating techniques, permitting the bending, forming, and assembly of complicated and intricate structural parts, with either laminated or plywood constructions.

He stressed the fact that, "There seems but little doubt also that postwar developments will bring new combinations of the older established materials and the variety of new products yet to come, now under development, or already on the market, to afford constructions and uses that strikingly take advantage of the best qualities and properties of each for a given purpose. Effective progress and success already made in bonding wood to metal, for example, presage many applications and unique uses."

In connection with the future forest supplies, Mr. Markwardt said, "Nature is both a strict taskmaster and a generous producer. Trees are a crop that, with even scant encouragement, are ready to grow and reproduce in kind. Perpetual crops can be ours by merely learning to cut timber selectively, so that only trees of a desirable size are cut, leaving a continuing stand for continuing industries, or by other approved and tried cutting practices."

He closed:

"And then, above all, research must continue to carry the burden of providing the needed data, new developments, and new conceptions that will make wood and its host of related products even more than ever before the versatile servant of man in the more complex and changing modern world."

AWARD OF DUDLEY MEDAL

In presenting Walter Bonsack, Chief Metallurgist, National Smelting Co., the winner of the Charles B. Dudley Medal to the President, Sabin Crocker, The Detroit Edison Co., chairman of the Award Committee, serving with Messrs. C. S. Reeve, Allied Chemical and Dye Corp., and J. R. Townsend, Bell Telephone Laboratories, Inc., mentioned that the medal, named in honor of the first A.S.T.M. president who was a pioneer in materials technology, was conferred in recognition of original contributions of research and that its purpose was to stimulate research and to encourage presenting the results of investigations that extend the knowledge of engineering materials. Mr. Crocker said,

"Of the several excellent papers presented during the past year which represent original contributions on research in materials, your committee

came to the unanimous conclusion that Mr. Bonsack's "Discussion of the Effect of Minor Alloying Elements on Aluminum Casting Alloys" is both outstanding and timely. The author discusses several questions which are particularly important now because of the emergency created by the war and the important part played by aluminum alloy castings in aircraft construction and armament work. Not finding all the answers in the existing literature which he surveyed exhaustively as attested by the extensive bibliography appended to the paper, the author turned to statistical analysis of test results of several thousand melts obtained in connection with his work as Director of Laboratories at the National Smelting Co. in Cleveland.

"The paper concerns the effect of impurities or stray alloying elements in commercial aluminum alloy castings covered by A.S.T.M. specifications. It deals with both physical and corrosion-resistant properties, considering castability, machinability, heat treatment, and stability at elevated, subnormal, and room temperatures. Concrete conclusions are drawn as to whether various amounts of different alloying elements are beneficial or harmful, or possibly neutral, in how they affect the desired properties. These conclusions should have a definite economic value in furthering a better utilization of available aluminum supplies, including a more intelligent use of remelted aluminum alloys."

It is of interest to note that Mr. Bonsack's paper was not presented at an annual meeting, but published in the August, 1942, ASTM BULLETIN. A few years ago it was decided to make such papers published in the BULLETIN also eligible for the award.

Mr. Bonsack, an American citizen since 1932, has been in this country since 1927, and affiliated continuously with the National Smelting Co. His activities have been concentrated on the development of various methods of producing and refining various aluminum and magnesium base alloys. His early technical training was obtained in Germany where he concentrated on research, consulting work and teaching. He is active in the work of several A.S.T.M. technical committees covering Die-Cast Metals and Alloys, B-6; Light Metals and Alloys, Cast and Wrought, B-7; and the Committee on Metallography, E-4.

Walter Bonsack, National Smelting Co., Dudley Medalist.



He is a member of the American Institute of Mining and Metallurgical Engineers; American Society for Metals; American Foundrymen's Association, Society of Automotive Engineers, and Society of Military Engineers.

This medal was the seventeenth to be awarded by the Society.

STANDARDIZATION AND RESEARCH

A measure of accomplishment in standards work is represented by the number of new specifications and tests approved at the meeting, which this year number about 50, comparing very favorably with 1941 and 1942, and on top of this has been constant work throughout the year on emergency specifications and provisions which are issued from week to week.

The accompanying table giving a summary of actions indicates notable progress in advancing tentative specifications and tests to become formal A.S.T.M. standards (subsequent to Society letter ballot on September 1) and numerous revisions in standards and tentative standards. Elsewhere in this BULLETIN is a comprehensive list of the new tentative standards with serial designations, which information is of distinct interest, and with this a note on the tentative standard withdrawn. Another list not published but which is nevertheless quite significant gives the titles of standards published in various committee reports for information and comment. A number of committees have used this practice in recent years, but not to the extent of 1943. Many of these proposed specifications and tests on which the committees would like to have the reaction of those concerned are in the preliminary stage of A.S.T.M. standardization.

In a separate mailing there is being sent to each member a letter ballot covering those actions involving the adoption of standards or changes in existing ones, this ballot being accompanied as customary by the *Summary of Proceedings* which gives detailed information on matters covered in the ballot, particularly any changes made at the meeting.

A study completed just before the meeting by Committee E-9 on Research indicated notable advancement in a large number of the Society's research investigations in both field and laboratory work. Several new projects considered of importance in the present emergency were initiated and pushed during the year. The Society executives and committee officers maintain that a great portion of this research work is most essential in connection with America's materials problems. Notable reports on research involved the work on atmospheric corrosion tests

A list of new tentative standards, with newly assigned serial designations, appears on another page of this BULLETIN. For a list of Emergency Alternate Provisions, see page 75.

of iron and steel wire and wire products, and on non-ferrous metals where latest test results of some 24 metals and alloys exposed for 10 years were reported.

SOCIETY'S CONTRIBUTION TO THE WAR EFFORT

In presenting the annual report of the Executive Committee, the Society's Secretary-Treasurer, C. L. Warwick, reviewed briefly what is considered the most important measure of the Society's accomplishments, namely, their contribution to the winning of the war. He cited the numerous emergency specifications and provisions established, many of them through cooperation with other organizations and Government bodies, particularly the Army, Navy, and War Production Board. The 1942 Book of A.S.T.M. Standards is indicated as a notable contribution and he cited numerous other fields where A.S.T.M., through its technical committees, had cooperated with Federal groups, specifications committees, WPB Conservation Division, etc. Many A.S.T.M. specifications and tests are incorporated in limitation orders, notably those covering certain steel products. Elaborating somewhat on one specific service was his brief description of the work of Committee D-20 on Plastics which during the past year after devoting some of the previous years to the perfection of test methods had begun writing specification requirements with some ten quality standards issued.

Mr. Warwick reported the Society's membership, standardization work, and finances at a peak and expressed the thanks of the Executive Committee for cooperation it had received from so many sources.

COMMITTEE DINNERS

Although no formal entertainment had been planned at the meeting, mention should be made of three interesting dinners sponsored by A.S.T.M. committees. The annual D-2 dinner, sponsored by A.S.T.M. Committee D-2 on Petroleum Products and Lubricants, has been held for many years and each year some outstanding authority in the petroleum field is the guest of honor—this year, A. E. Flowers, Engineer, In Charge of Development, The De Laval Separator Co., Poughkeepsie, N. Y.

SUMMARY OF ACTIONS TAKEN AT ANNUAL MEETING AFFECTING STANDARDS AND TENTATIVE STANDARDS.

	Existing Tentative Standards Adopted as Standard	Standards in Which Revisions Will Be Adopted	New Tentative Standards	Proposed Revisions of Existing Standards Accepted as Tentative	Existing Tentative Standards Revised	Tentative Standard Withdrawn	Present Total Standards Adopted	Present Total Tentative Standards
A. Ferrous Metals—Steel, Cast Iron, Wrought Iron, Alloys, etc.	2	8	1	2	1	..	157	34
B. Non-Ferrous Metals—Copper, Zinc, Lead, Aluminum, Alloys, etc.	10	4	7	..	15	..	64	92
C. Cement, Lime, Gypsum, Concrete, and Clay Products	7	..	..	..	2	1	116	41
D. Paints, Petroleum Products, Paper, Textiles, Rubber, Soap, etc.	31	8	33	8	15	..	382	213
E. Miscellaneous Subjects, Testing, etc.	2	1	..	..	..	..	20	28
Total	52	21	41	10	33	1	739	408

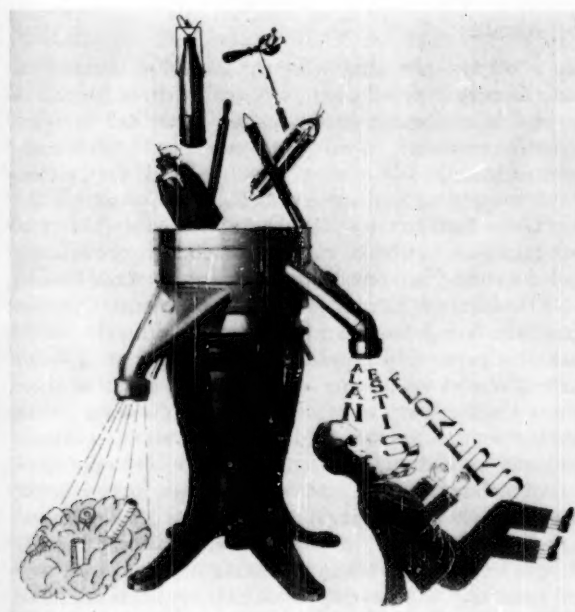
The new President, Dean Harvey, Materials Engineer, Engineering Laboratories and Standards Dept., Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., who has been extremely active in the work of Committee D-9 on Electrical Insulating Materials, was the surprise guest of honor at the D-9 dinner, and at the joint function sponsored by Committees E-2 and E-3 on Methods of Chemical Analysis of Metals, H. V. Churchill, Research Laboratories, Aluminum Co. of America, New Kensington, Pa., chairman of Committee E-2, was the honor guest.

Ferrous and Non-Ferrous Metals

Four of the fifteen formal sessions were of particular concern to metallurgists and metals' testing engineers. In the Symposium on Hardness Testing, a number of participants stressed the importance of correct use of this test with respect to specifications and interpretation of results. One authority emphasized the necessity of more reliable hardness conversion tables and commended one of the Society's committees which has developed hardness conversion tables for cartridge brass and is now working on tables for certain steels.

Two notable and related papers described new methods of interpretation of creep test data (McVetty), and working stresses of alloys at elevated temperatures (Nadai and McVetty, Westinghouse Electric and Mfg. Co.). McVetty stated the basic objectives of all high-temperature testing to be the comparison of materials and the choice of safe working stresses. Creep testing occupies an important place in this field since it provides data for a large number of applications in which the criterion of failure is not actual rupture but the attainment of a specified small allowable deformation within the life of the material in service. This paper bases the interpretation of creep test data upon the establishment of relations among the four variables—temperature, stress, deformation, and time. He developed practical interpolation and extrapolation methods, and illustrated the method by establishing creep curves from eight tests of a 35 per cent nickel, 19 per cent chromium-heat resisting alloy. The paper by Nadai and McVetty describes a new chart for working stresses at elevated temperatures and is based on the hyperbolic sine function for expressing the dependence of the rate of flow on the stress. The work of these two men should result in con-

(Continued on page 10)



Annual Meeting Remarks by F. B. Bell

IT IS PERHAPS worth while in this month of June, 1943—the anniversary of the collapse of all the Armed Forces facing Germany, the anniversary of Dunkirk—to recall the situation that then faced the world as compared with our present situation.

The Belgian Army had capitulated, the French Army had collapsed, and the British who escaped the holocaust of Dunkirk returned to their own shores without their armor and their artillery. They returned to a country whose industrial resources had been sorely tried to supply the fighting tools which they had abandoned. Truly it seemed that the defenders of liberty had been routed, and that we might become her only guardian—a continent defending itself against a hostile world.

This anniversary shows a different prospect. The Allied nations, united as never before, are armed with tools of war of unsurpassed quality and in quantities adequate for a global war. Three years ago this country assumed the task of becoming the arsenal of the world, and the results obtained are beyond our ordinary methods of measurements. Credit for having put into the field the best-housed, best-fed, best-trained, and best-equipped Army the world has ever known belongs to America. No group or class should attempt to monopolize it.

However, at this meeting of the American Society for Testing Materials, it seems fitting that we should mention the part that this organization has played in making this great industrial accomplishment possible. As one of the most important tools with which our industrial system has operated in the past, you have been at work both as individuals and as a Society, endeavoring to answer the call for more and better production.

Since the last war, this country not only neglected ordinary security measures, but intentionally weakened her defensive position. However, the Ordnance Department of the Army of the United States has always recognized its dependence on industry; and, throughout the years since the last war, has spent much of its thought and some of its small peacetime appropriation to keep industry informed as to its problems, and to provide plans and methods by which full cooperation with industry could be obtained. Your membership and your Society have been constantly alert to aid in this work.

When this present conflict ends, our people will be weary of war with its controls and sacrifices. Again will come the demand for the elimination of everything that pertains to war and national defense. You who know something of the benefits obtained from our years of work on industrial preparedness must then be alert to do your part in maintaining that close cooperation between industry and our Service Forces—which, in times of peace, is our best guarantee of peace; and in time of war, has proved itself our only assurance of victory.

Facsimiles of Illustrations on Covers of Committee Dinner Programs in Pittsburgh.

Left shows Committee D-2 cover picture with petroleum testing equipment going into the De Laval separator and the 1943 honor guest, Dr. A. E. Flowers, coming out of the cream spout, while from the milk discharge a collection of bolts, nuts, etc. Doctor Flowers is Engineer, in Charge of Development, The De Laval Separator Co., and a long-time committee member—see article in this Bulletin on "Long-Time Society Committee Members."

On the right, the very simple, but very effective cover design showing a silhouette of the new President, Dean Harvey, who was guest of honor at the Committee D-9 dinner. The obtaining of this silhouette involved some problems in order that the subject would not be aware of the purpose in mind.





E. S. Dixon, The Texas Company; W. L. Bowler, The Pure Oil Co. • Front: L. S. Marsh, Inland Steel Co.; C. F. Goodrich, American Bridge Co.; Back: G. E. Baumgardner, Norfolk & Western Railway Co.; R. W. Lilley, Worth Steel Co. • H. J. Kerr, The Babcock & Wilcox Co.; H. B. Oatley, The Superheater Co.; Edwin Joyce, Conservation Division, WPB.

siderable saving of time by those requiring creep test data and an evaluation of its significance.

McAdam and Mebs, National Bureau of Standards, contributed an extensive paper dealing with cohesive strength of metals at low temperatures. The authors gave data on strength of metals at room and at low temperatures and give a basis for interpreting the influence of low temperatures on the properties of various specimens. Quantitative variation of cohesive strength was studied and indicated that a temperature scale of equal thermodynamic efficiencies reveals relationships of considerable theoretical and practical importance.

An interesting paper on fatigue tests of some copper alloys in wire form was given by Burghoff and Blank, Chase Brass and Copper Co., which showed that several had endurance limits ranging from approximately 30,000 to 40,000 psi. at 100,000,000 cycles. Tin, nickel, and silicon enhance the endurance properties of these copper alloys in varying degrees, and in some instances small additions of these elements appear to be as effective as larger amounts. An age-hardened and severely drawn copper-nickel-phosphorus alloy has particularly attractive properties. All of these results indicate the feasibility of several alloys, high with respect to endurance strength, but low with respect to content of critical alloying elements as compared with the commonly used phosphor bronzes.

Montgomery and Urban, Lunkenheimer Co., in their paper on structure and creep characteristics of cast carbon-molybdenum steel at 950 F. stated that interrupted quenching had been utilized to obtain pearlitic and acicular structures in both fine- and coarse-grained cast carbon-molybdenum steel. This eliminated the effect of grain size. The creep tests show that the coarse-grain acicular structure is the best in creep-resisting properties and the fine-grain pearlitic the poorest.

Corrosion and Electrodeposited Coatings:

Two outstanding contributions in the session devoted to corrosion and electrodeposited coatings were voluminous reports by the Society's two corrosion committees, B-3 on Corrosion of Non-Ferrous Metals and Alloys and A-5 on Corrosion of Iron and Steel giving, respectively, data of long-time outdoor tests of non-ferrous metals and of steel wire and wire products.

A report of 24 non-ferrous metals exposed to atmospheric corrosion for periods of 1, 3, 6 and 10 yr. had been prepared by Committee B-3. While the elaborate tables and other data have been studied in detail by the committee, the publication of interpretation of results is being deferred until the tension test on the specimens cut from the chemically cleaned 9 by 12-in. plates have been completed. It is planned to include in next year's report conclusions covering the test results to date.

The research project on steel wire and wire products, one of the most extensive the Society has under way, is discussed in the Committee A-5 report, material having been on exposure for six years at eleven widely different locations. The committee has included pertinent comments on the extensive data which relates to zinc-coated unfabricated wire, unfabricated wire carry-

ing coatings other than zinc, barbed wire, farm-field fence, chain-link fence, and wire strand.

In a technical paper by Tracy, Thompson, and Freeman, American Brass Co., describing ten-year atmospheric corrosion tests on several brands of copper in the form of sheet and wire, the differences in resistance to atmospheric corrosion of the several types of copper were found to be small and probably have no significance in relation to service life.

A paper by Gustaf Soderberg on properties of plated lead coatings on steel should assist users of the new A.S.T.M. Emergency Specifications for Electrodeposited Coatings of Lead on Steel (ES-31) in choosing the proper type of coating for each individual application. The paper presents information gleaned from the literature together with private findings not published heretofore. Since exposure test data for lead coatings are somewhat meager, there are included some test results on the corrosion of solid lead and on the corrosion of steel and other metals in contact with lead. These results throw further light on the general subject.

The salt spray test for determining corrosion-resisting properties of various types of solids and plated non-ferrous metals has been frequently misused and misinterpreted. A discussion of the use and misuse of this test as applied to electrodeposited metallic finishes was given by C. H. Sample. When thoroughly standardized and properly conducted the salt spray test is frequently useful in evaluating the degree of porosity of electrodeposited metallic coatings of the electropositive type. The lack of experimental data correlating salt spray and service behavior of the wide variety of coating-basis metal combinations would indicate that except for revealing particularly inferior coatings the test does not merit its current extensive use in specifications. (See paper and discussion in this BULLETIN.)

Non-Ferrous Metals:

Included in the 12 items comprising the session on non-ferrous metals were reports from all of the "b" committees (with the exception of Committee B-3 on Corrosion which had been assigned to another session). Two groups concerned with Chemical Analysis of Metals and Spectrographic Analysis, Committees E-3 and E-2, respectively, also were included. Committee B-1 on Copper Wires for Electrical Conductors reported that since insufficient data were available, no test for ductility of coating was included in the Emergency Specifications for Lead-Coated and Lead-Alloy-Coated Copper Wire for Electrical Purposes (ES-1a) and even now there is not sufficient background.

In a technical paper C. J. Snyder, Anaconda Wire and Cable Co., described results when wire was coated in baths of three different binary tin-lead alloys. It was shown that when a bath of 10 to 66 per cent tin, remainder lead, was used, the coatings were segregated with the tin concentrated near the copper and the lead concentrated on the surface. Coatings from a 5 per cent tin-lead bath were not segregated. All these coatings, however, were relatively "sticky" in stranding and insulating operations. A new lead alloy containing small amounts of tin, cadmium, and antimony was developed for this application. This

new alloy-coated wire more nearly approaches tinned wire in physical properties than any other tried. It can be applied with standard equipment, and a method of control to keep the coating uniform was worked out. Data show that substitution of this alloy saved 87 per cent of the former tin consumption.

Committee B-5 on Copper and Copper Alloys, which has done such outstanding work in connection with the war effort, submitted a number of revisions in both standards and tentative standards and also recommended that four tentative specifications be adopted as formal A.S.T.M. specifications. The latter cover Copper Pipe, Standard Sizes; Seamless Copper Tubing, Bright Annealed; Manganese Bronze Rods, Bars and Shapes; and Leaded Red Brass Rods, Bars and Shapes.

It was reported that the committee has agreed on drafts of three specifications for beryllium copper intended to replace existing specifications. The new specifications cover (1) sheet and strip, (2) rods and bars, and (3) wire. One of the phases of the work in which there has been intensive work has been copper-base alloys for sand castings. The subcommittee headed by Dr. G. H. Clamer held an extended meeting in Pittsburgh and a number of modifications are anticipated.

Electrical Heating, Electrical-Resistance and Electric-Furnace Alloys:

The work of Committee B-4 on Electrical Alloys resulted in a new test for density of fine wire and ribbon for electronic devices. This procedure gives the density of wire ranging from 0.010 to 0.001 in. in diameter, or ribbons of similar thicknesses to an accuracy of 0.1 per cent. Another test which was approved covers the effect of controlled atmospheres upon alloys in electric furnaces. The test covers temperature at which the attack occurs and effect of stress on nature or rate of attack. Another interesting test involves the life test of electrical contact materials as indicated by the loss in weight of contact material due to arcing, change in combined length of each pair of contacts, temperature rise of the stationary contacts during operation, direct-current voltage drop across pairs of contacts at intervals throughout the test, and observation of the welding tendencies.

The fourth item given in the report, but later withdrawn by Committee B-4 would have provided a new tentative specification for chromium-nickel-iron alloy castings for high-temperature service in electric furnaces. This covers the 24 per cent chromium, 12 per cent nickel class suitable for service up to 2000 F. Later action is expected.

A notable development in the work on light metals and alloys is covered by Committee B-7 in new tentative specifications for aluminum sheet and plate for use in welded pressure vessels. The committee also included in its report a discussion by J. D. Edwards on "A Comparison of the Performance of Anodic Coatings on Wrought Aluminum Alloys when Exposed to Salt Spray and to the Weather." The results, generally speaking, indicate, that while salt spray exposure tests may discover coatings subject to early failure, still the resistance of most anodic coatings to this type of exposure is sufficiently extended so that the method could scarcely be considered an accelerated test. Extensive research investigations under way are to be continued before final conclusions are drawn.

There were two interesting technical papers dealing with solders. One, recommendation on conservation of tin in soft solders where the authors D. L. Colwell and W. C. Lang, WPB, Washington, pointed out that in the absence of a plentiful supply of tin much of the work formerly done by high-tin solders can be just as satisfactorily performed by solders of alternate compositions containing either no tin at all or much less tin than was previously used. Typical compositions are given and suggestions are made for the proper handling of these various alternate compositions. It is felt that much of the residual demand for high-tin solders can be eliminated if proper methods of using alternate compositions are installed. (See paper—page 37.)

The other discussion by Kies and Roeser, National Bureau of

Excerpts from Address on "Maintaining Quality Under Wartime Conditions" by A. H. Phelps

MR. PHELPS, Vice-President, Westinghouse Electric and Manufacturing Co., referred to the election of Dean Harvey, Materials Engineer of his company, as the new A.S.T.M. president, as indicative of the continued interest between the Society and his company begun in 1899 when the Second A.S.T.M. Annual Meeting was held in Pittsburgh. He referred to the almost half a century of cooperation as demonstrating the vitality of this cooperative effort. In stating the constant aim of his company that "Quality must be built into the product" he said:

In delivering a quality product, it is a foregone conclusion that this product must be built by competent engineers, skilled workmen, and from quality raw materials. The American Society for Testing Materials, during its history, has developed more than 1100 standard specifications. Our company, striving toward an ever-improving goal, uses more than 40 per cent of A.S.T.M. standards to obtain quality in raw materials.

"Westinghouse regards A.S.T.M. as a practically indispensable aid in achieving the high standard in our manufacturing which our history and future demands. This viewpoint regarding the usefulness of your Society is shared by industry throughout the United States. The standards you have been able to set and maintain have practically become the Ten Commandments for the better industries of the United States. American industry, as has been most recently demonstrated in the manufacturing for our war effort, is the wonder and the hope of the world. This, in no small measure, is due to the reliable standards which your organization has untiringly developed and advocated. For these and many other things industry gives thanks to you."

He then pointed to a number of emergency problems in connection with shortages and necessity of substitutes or alternates, including scarcity of the particular wood alcohol from which formaldehyde was manufactured, so essential in making plastics; the necessity of lowering tin content in Babbitt metal; the use of carbon and low alloy steels in place of higher alloy steels in various applications; the substitution of a synthetic resin for shellac; evolving an American-made, high-grade tissue paper for the electrical insulating industry.

In closing, he referred to the present distorted supply and demand factor; the complications involved in Government control; and other problems which make it very hard to predict what will happen during the next one, two, or three years, but he said:

"There are certain fundamental principles on which we can bank; first, people will be very much as they have been—with desires, appetites and longings to be satisfied. These natural instincts will be satisfied in the future very much as they have been in the past. If these are to be met to the satisfaction of at least a majority of our 135,000,000 people, it will be essential that the best in the brains of our engineers, our chemists, business men, and our Government officials be used to make possible the continuation, the development, and advancement of our production machine. Our position is further complicated by the fact that America, in the new world order, will likely mean that she must become more world-minded and this adds greatly to the complications involved in predicting what may happen.

"We do not agree with those calamity men of today who maintain that America's renaissance is past and that our standard of living must decline. We regard those in the same category as the group which attempted to create prosperity by restricted production and distributing less to more people. We feel that America's hope and the world's hope for the future lies in using our productive brains, manpower, facilities, and natural resources to the optimum and thereby raising not only our own standard of living, but the standard of living of our neighbors in the world economy."

Standards, covered "The Testing and Properties of Low-Tin Solders Listed in Recent Federal Specifications." In this study of six solders emphasis was placed on two with 20 per cent tin content, one was commercial 50-50 solder. The authors showed that almost 15 per cent more by weight of either solder G or M

(Continued on page 13)



W. H. Finkeldey

E. W. McMullen

F. G. Tatnall

T. A. Boyd

E. O. Rhodes

NEW OFFICERS

THE RECENT ELECTION of officers, as announced at the annual meeting by the tellers, W. A. Graham and H. G. Burnham, resulted in the unanimous election of Dean Harvey as President (1943-1944), J. R. Townsend as Vice-President (1943-1945), and the following as members of the Executive Committee (1943-1945): T. A. Boyd, W. H. Finkeldey, E. W. McMullen, E. O. Rhodes, and F. G. Tatnall.

PRESIDENT

Dean Harvey, the new President, Materials Engineer, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., a graduate of Armour Institute of Technology (B.S., 1900; E.E., 1905) has since 1904 been affiliated with the Westinghouse organization. From 1911 he has served as Materials Engineer on the application of materials and development of specifications and methods of tests. For the past twenty months, he has been devoting several days weekly to War Production Board work in Washington as a Consultant in the Conservation Division concerned chiefly with electrical and mechanical work. He has been extremely active in A.S.T.M. work serving as Chairman of Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys since 1926. He is currently very active in Committee D-9 on Electrical Insulating Materials (formerly Vice-Chairman) and is Chairman of the Subcommittee on Plates, Rods and Tubes. He is also Chairman of the Textile Committee's (D-13) Subcommittee on Glass Textiles and formerly served on committees concerned with steel and copper products. He has served as a member of the Society's Committee on Papers, was a member of the Executive Committee, and Vice-President of the Society from 1941 to 1943. He is active in the work of the American Standards Assn. particularly as it involves insulated wires and cables. His technical contributions have been published in the A.S.T.M. *Proceedings* and elsewhere including the *Electric Journal*. In addition to A.S.T.M., he holds membership in the American Institute of Electrical Engineers and Tau Beta Pi.

Recently Mr. Harvey was honored by receiving the Westinghouse Award of Merit for distinguished service in developing materials and process specifications, for notable work in connection with insulating oils, and for his contributions to the war effort in the WPB Conservation Division.

VICE-PRESIDENT

J. R. Townsend, Materials Standards Engineer, Bell Telephone Laboratories, Inc., New York, N. Y., was born in Baltimore, Md., and attended Baltimore City College, later Brooklyn Polytechnic Institute. After experience with the Bethlehem Steel Co. and the Mathematics and Dynamics Branch of U. S. Army Ordnance in World War I, he, in 1919, became a member of the Technical Staff of the Western Electric Co., and since 1925 has been Materials Standards Engineer of the Bell Telephone Laboratories, Inc. He is the author of numerous technical

papers and reports. In 1930 he was awarded (jointly with W. A. Straw and C. H. Davis) the A.S.T.M. Charles B. Dudley Medal for the outstanding paper on "Physical Properties and Methods of Test for Some Sheet Non-Ferrous Metals." In addition to A.S.T.M., he is a member of the American Welding Society, the American Society of Mechanical Engineers, and the Editorial Staff of *Journal of Applied Physics*. He is a Consultant for the National Research Council, National Defense Research Committee, and the War Production Board. Mr. Townsend has been extremely active in many fields of work of the Society. He is Chairman of Committee B-6 on Die Cast Metals and Alloys, and his term of office on Committee E-10 on Standards has just expired—he was Chairman of this important committee for two years. His other committee affiliations include Committees B-2 on Non-Ferrous Metals and Alloys, A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, E-1 on Methods of Testing (Chairman of the Section on Indentation Hardness), and the Research Committee on Fatigue of Metals.

MEMBERS OF EXECUTIVE COMMITTEE

T. A. Boyd, Head, Fuel Department, Research Laboratories Div., General Motors Corp., Detroit, Mich., received his Bachelor of Chemical Engineering degree from Ohio State University in 1918 (his degree of Ch.E. was received in 1938). Beginning in 1918 he was Research Chemist, Dayton Metal Products Co., and when the Research Division of this organization became a part of the General Motors Corp. in 1920 forming the basis of its central research division Mr. Boyd continued in this work. Since 1923 he has been head of the Fuel Department. His research work has been concentrated chiefly on automobile and aircraft fuels and their efficiency. He was codiscoverer with C. F. Kettering and Thomas Midgley, Jr., of the antiknock effects of the liquid compounds of lead. The author of a large number of technical papers he has also prepared various popular reports and articles and two books, one on "Gasoline—What Everyone Should Know About It" and the other "Research—The Pathfinder of Science and Industry." A member of A.S.T.M. for many years he has served as chairman of Committee D-2 on Petroleum Products and Lubricants, since 1932. He is also a member of the Detroit District Committee. He is a member of a number of technical and professional societies including the following: American Chemical Society, Society of Automotive Engineers, American Petroleum Institute and Engineering Society of Detroit (member, Board of Directors and Second Vice-President).

W. H. Finkeldey, Member of Firm, Singmaster and Breyer, New York, N. Y., a native of Philadelphia, Pa., is a graduate of Pennsylvania State College with a Bachelor of Science degree in Mining (1915); following this he did graduate work at Columbia University in 1916. Later he was assistant mining engineer on a project in Cuba. From 1917 to 1927 he was with the Research Division, New Jersey Zinc Co., Palmerton, Pa., as Metallurgist, Head of the Metal Section and Assistant Chief, and since 1927 he has been in the firm of Singmaster & Breyer.

Mr. Finkeldey has been intensely concerned for many years with the work of A.S.T.M. involving corrosion of ferrous metals and alloys (Committee A-5) and non-ferrous metals (Committee B-3). As an active member and officer of these committees (past chairman of Committee

A-5), he aided in planning and in carrying out a number of the very extensive research projects under way. At the present time he is chairman of the A.S.T.M. Advisory Committee on Corrosion responsible for coordinating and advising other technical groups on research and corrosion testing work. He also serves on Committees B-6 on Die-Cast Metals and Alloys and A-10 on Iron-Chromium-Nickel and Related Alloys. In addition to A.S.T.M., he is a member of the American Institute of Mining and Metallurgical Engineers, British Institute of Metals, and the American Electrochemical Society.

E. W. McMullen, Director of Research, The Eagle-Picher Lead Co., Joplin, Mo., following his graduation from Armour Institute of Technology in 1909 with the degree of B.S. in Chemical Engineering, was instructor in industrial chemistry and metallurgy, receiving his Ch.E. degree in 1913. Then for 15 years he was Technical Director of the Simmons Co., in Kenosha, Wis.; later was Chemical Engineer of the Celotex Co., Chicago, and for four years was Technical Director and Plant Manager of The Ault & Wiborg Corp., Cincinnati, Ohio. He has been Director of Research with his present company for the past eight years. In the Society Mr. McMullen has been particularly concerned with the work of A.S.T.M. Committee D-1 on Paint, Varnish, Lacquer, and Related Products, having been active in the work for almost 20 years. At present he is concerned with projects in eight of its subcommittees. He also served for several years on Committee C-16 on Thermal Insulating Materials. In addition to A.S.T.M. he is a member of the American Chemical Society and American Society of Heating and Ventilating Engineers.

E. O. Rhodes, Technical Director, Koppers Co., Tar and Chemical Div., Koppers Building, Pittsburgh, Pa., following his preparatory school training in Dodge City High School (Kansas), his birthplace, received his B.S. in Chemical Engineering from the University of Kansas in 1912, and his Ch.E. the following year. For the next eight years, through 1921, he was Industrial Fellow at Mellon Institute, Pittsburgh, working on edible oils and butter substitutes, electrothermic reduction of alumina, potash recovery from portland cement manufacture, and problems relating to the manufacture of carbon electrodes. Until 1925

he was Technical Director, American Tar Products Co., Chicago, and since that time has been in his present position. He has prepared a large number of papers and reports on the manufacture, testing and use of coal tar products, and he holds numerous patents. In A.S.T.M. his technical activities have been concentrated particularly in Committees D-4 on Road and Pavement Materials, D-8 on Bituminous Waterproofing and Roofing Materials, and D-18 on Soils for Engineering Purposes. He is a member and officer of numerous subcommittees of these standing groups. He also represents his company on Committee D-1 on Paint, Varnish, Lacquer, and Related Products. Mr. Rhodes is a member of numerous professional societies and clubs including the following: American Chemical Society, American Wood Preservers' Assn., American Railway Engineering Assn., and Highway Research Board.

F. G. Tatnall, Manager, Testing Equipment Dept., Baldwin-Southwark Div., The Baldwin Locomotive Works, Philadelphia, Pa., is a graduate of the University of Pennsylvania with the degree of B.S. in Mechanical Engineering, 1920 (in 1925, the University awarded him the degree of M.E.). Mr. Tatnall was for several years field engineer with the Foamite Childs Corp., Utica, N. Y., during which he traveled extensively throughout North America. Following this, he was Assistant to the President, Richle Brothers Testing Machine Co., Philadelphia. He has been connected with his present organization since 1926. He is widely known throughout the United States and Canada because of his extensive activities in the testing and research apparatus field. He has been a member of A.S.T.M. for a number of years and is the present chairman of the Philadelphia District Committee and also serves on several of the technical committees including D-20 on Plastics, D-9 on Electrical Insulating Materials, D-18 on Soils for Engineering Purposes, and the Sections on Speed of Testing and Elastic Strength of Materials of Committee E-1 on Methods of Testing. He is a member of a large number of organizations including the American Society for Metals (past-chairman of the Philadelphia Section), Franklin Institute (Committee on Science and the Arts), American Concrete Institute, Society for Promotion of Engineering Education, Institute of Aeronautical Sciences, and American Institute of Mining and Metallurgical Engineers.

Annual Meeting

(Continued from page 11)

than of 50-50 solder is required to fill a given space. The high liquidus temperatures and wide melting ranges of the lower tin solders complicate the technique of soldering but do not preclude their use for most handwork where 50-50 solder was formerly used. The average strength of lap joints in sheet and strip specimens made with solders having only 20 per cent tin appeared quite satisfactory for practical purposes. In short-time tests of single lap joints there was little difference in the strengths of joints in any one material made with the six different solders. It was evident that shear strength is not always the proper term to use in evaluating the strength of a single lap joint as ordinarily made in the shop or field.

Chemical Analysis of Metals:

Many members of the Society concerned with chemical analysis have participated in the intensive work during the year by Committee E-3 in developing several new and revised methods and preparing the new A.S.T.M. Volume on "Chemical Analysis of Metals" which has been under way for over a year. At the meeting the Society accepted new tentative recommended practices for apparatus and reagents for chemical analysis of metals. Detailed descriptions of recommended apparatus and detailed instructions for the preparation of standard solutions and certain nonstandardized reagents are included. An identifying number has been assigned each apparatus and reagent for convenience of reference in the analytical methods. Included also

are general recommendations on the purity of reagents and precautions on the use of hazardous reagents.

In its forthcoming publication, the committee plans to include new methods approved during the year covering chemical analysis of tin- and lead-base solder metal and analysis of zinc-base die-casting alloys; also the new procedure for determining selenium in steel.

Cementitious Materials and Concrete

Continued intensive interest in many problems in the field of cement, concrete, and concrete aggregates was evident from the two technical sessions devoted to these subjects and from the very excellent attendance and discussion at the large number of technical committee meetings preceding the sessions.

Two actions recommended by Committee C-1 on Cement were approved by the Society session—one, a change in the tentative test for compressive strength of portland-cement mortars (C 109), the principal modification being an increase in the tolerances for the distance between opposite faces of used molds for the 2-in. cubes (2 ± 0.02 in.). Of interest also was the approval to refer to Society letter ballot for adoption as standard the Tentative Method of Test for Autoclave Expansion of Portland Cement (C 151 - 40 T) with some changes. In its development stages and during approval as a tentative test the question of autoclave expansion received very intensive discussion and there were many differences of opinion concerning it.

The printed C-1 report included a most interesting discussion or notes on the effect of alkali in cement on the durability of concrete with contributions from Messrs. R. F. Blanks, W. C. Hanna, F. H. Jackson, and others and an appended bibliography

compiled by Mr. Blanks. In Pittsburgh there was an open sub-committee meeting on this subject at which interested parties exchanged notes and comments on problems involving concrete disintegration.

A study was given by Shartsis and Newman, National Bureau of Standards, of the heat of solution procedure for determining the heat of hydration of portland cement. The reproducibility measurements made in accordance with Federal Specifications SS-C-158a were described and also data, obtained by a modified method, found to be more precise. The temperature coefficients of the heat of solution of a dry cement sample and of the hydration of portland cement were found to be -0.2 and $+0.1$ cal. per g. per deg., respectively, in the range 20 to 30 C. The authors discussed a number of proposed changes and additions to the Federal Method.

J. C. Pearson, Lehigh Portland Cement Co., gave a most interesting discussion on "Measurement of Bond Between Bricks and Mortar" describing an extensive research which was undertaken to develop better methods of test and particularly to develop a method imitating job conditions and manipulation without involving too many uncontrolled variables. As a laboratory test, a mechanized assembly of the old cross-brick couplet was found to give the most satisfactory results for bond in tension. Another test, developed with the aid of an experienced bricklayer, consisted in prying up bricks, laid in mortar on the top of a wall, with a lever under measured load, thus permitting calculation of the stress at rupture. Analysis of many test results from the two methods showed that the couplet test is the more reliable, and that it responds to the plasticity of the mortar somewhat more favorably than the so-called wall test.

In another paper data were presented by Messrs. Muhlenbruch and Marcin, Carnegie Inst. of Technology, on "Increasing the Reflectivity of Standard Portland Cement Concretes by Additions of Hydrated Lime." Using 30 per cent hydrated lime addition, reflectivity could be raised 15 percentage points.

An interesting paper presented by S. P. Wing and Arthur Ruettgers, U. S. Bureau of Reclamation, covered variations in strength of portland cements conforming to the same specifications and the relation of such variations to concrete control. The paper deals with an analysis of variations in the 28-day strength properties of ten low-heat portland cements purchased for a large dam under the same specifications, and with the effect and practical significance of such variations on the strength uniformity of concrete. Mill strength levels ranged from 2830 to 5000 psi. For cement from a single mill, the average coefficient of variation in strength was 13.5 per cent. Among the conclusions is this—that cement strength differences revealed by cement acceptance tests are of importance in the building of structures for which the concrete must meet a minimum 28-day or other early strength requirement, but that they are likely to have little bearing on the ultimate strength differences in massive dams or other structures in which the concrete is subject to prolonged hydration and strength development.

Concrete and Concrete Aggregates:

There was much interest in each of the technical papers on concrete and concrete aggregates. Douglas McHenry, U. S. Bureau of Reclamation, in a fundamental paper, covered the problem of creep in concrete and the application of his principles to design. He also described numerous laboratory tests which formed the basis and verification of his theory. He developed an equation which defines creep as a function of stress, age at loading, and elapsed time after loading, which equation combined with superposition principles gives a means for expressing the strain history when the stress history is known.

A simplified test for evaluating effectiveness of concrete mixers was described by Wing, Jones, and Kennedy of the U. S. Bureau of Reclamation, as based on a study of more than 2000 analyses of fresh mortar and tests from 220 batches of concrete mixed in eight

different mixers. The authors conclude: "The unit weight test is a simple test which is well adapted for determination of the amount of mixing necessary to produce a desired degree of uniformity. It provides coefficients indicative of the batching and mixing efficiencies and indicates where improvements can be made in the mixing procedures. For a given uniformity and operating at the same percentage of critical speed, concrete mixers of different sizes require mixing periods directly proportional to the squares of their diameters."

In another paper, Messrs. Hubbard and Williams concluded on the basis of extensive tests that the abrasion of blast-furnace slag, whether measured by the modified Duval or Los Angeles methods, does not predict the strength-producing value of the material when used as concrete aggregate. The characteristics of slag from 15 sources have been studied together with strength tests of the concrete resulting from their use. The unit weight of the slag does not predict the strength of concrete or the abrasion loss of the slag aggregate. Abrasion tests of slag show a marked similarity between the results of the Los Angeles and Duval methods, although there is a difference in the magnitude of the results.

While not presented in the session on concrete, a paper by C. H. Menzel, Portland Cement Association, is of much interest covering tests of fire resistance, and thermal properties of solid concrete slabs and their significance. This most extensive contribution describes a large number of tests carried out on 16 solid concrete slabs which carried loads of 400 and 500 psi. during exposure to fire. The test developed important data on the thermal properties of solid concrete made with various aggregates.

The relationships between fire endurance period and the air-dry weight per sq. ft. of the solid concrete slabs is similar to the relationships developed in tests of walls of hollow concrete masonry units where it was found that the fire endurance period increased as an exponential function of the average air-dry weight per sq. ft. of wall assembly.

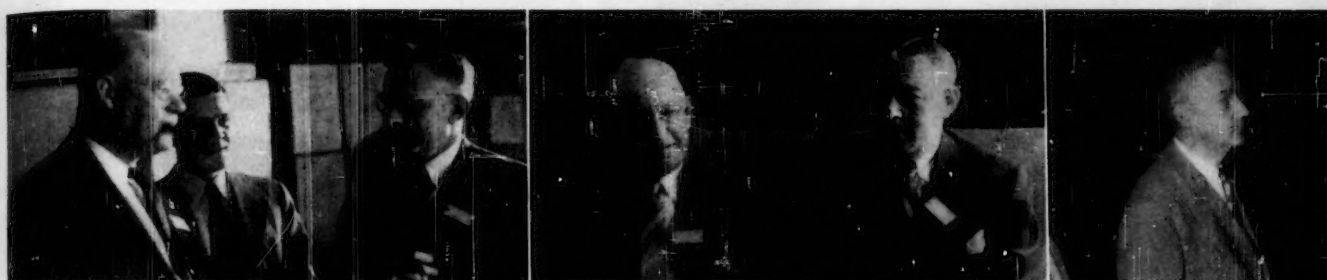
Comparison of these relationships indicates that pound for pound the relatively dense concrete in the solid slabs was from 15 to 30 per cent less effective in retarding temperature rise on the unexposed face in the case of the two natural aggregates (siliceous and calcareous gravel) than the corresponding dry-tamped concrete in hollow masonry walls. The Haydite concrete was from 10 to 40 per cent more effective in the solid slabs than in the walls of hollow masonry units. The greater effectiveness of the Haydite concrete in the solid slabs is mainly due to tenaciously held moisture within the thicker Haydite slabs.

Study of the allowable steel stresses used in conventional design practice and of published data on the general effect of elevated temperatures on the yield strength and elastic properties of carbon steels indicates that 1000 F. is the critical temperature for carbon steel reinforcement in flexural concrete members.

The fire endurance period of solid reinforced concrete floor slabs may be expected to be closely related to the approximate time to attain critical temperatures in the reinforcing steel nearest the exposed face.

Paints, Varnish, Lacquers

The approval of three important tests for properties of traffic paints, agreement on five new methods of chemical analysis of various pigments, and new tests for evaluating degree of blistering of organic coatings were important accomplishments as a result of the work of Committee D-1. The three tests of traffic paints covering conduct of road service tests, light sensitivity, and dry to no-pickup time, were developed in a special sub-committee. This group has accumulated considerable data on laboratory tests *versus* road durability tests. It is working on immersion tests and bleeding properties of traffic paints. The road service test is to be made under actual road conditions;



F. E. Foster, Grinnell Co. (behind pipe bowl); F. W. Davis, E. B. Badger & Sons Co. • H. H. Craver, Pittsburgh Testing Laboratory; J. M. Weiss, Consulting Chemical Engineer • W. F. Fair, Jr., Mellon Institute

the light sensitivity test is intended to determine color changes produced by sunlight on paint material; the third test is a laboratory procedure to determine drying time, and an actual small tire is used in the laboratory operating under prescribed procedures.

The new test for evaluating the degree of blistering of organic coatings on metal when subjected to immersion or other tests involving exposure to moisture or liquids includes photographic reference standards which are representative of different sizes of blisters that may develop on paint systems on iron, steel, or other metal surfaces. They are to be used for comparative purposes and are not intended to have a direct relationship to a decision regarding what constitutes failure of the paint system. This shall be agreed upon by the purchaser and seller. This is another in the series of methods being developed in the program of accelerated tests.

The five new methods of chemical analysis of extender pigments were developed in a subcommittee dealing with analytical methods. They cover the following materials: Mica Pigment, Diatomaceous Silica Pigment, Barium Sulfate Pigments, Aluminum Silicate Pigment, and Magnesium Silicate Pigment.

The committee announced it was continuing a number of its research investigations, including exposure tests covering an investigation of several methods of surface preparation of steel for painting. Further tests are planned to determine the effect of chemical pretreatment on steel which has been previously painted and then exposed to the atmosphere until rusting occurs.

Petroleum Products

A most extensive report as submitted by its Committee D-2 on Petroleum Products and Lubricants was approved at the A. S. T. M. Annual Meeting in Pittsburgh, on Wednesday, June 30. The recommendations included a new tentative test for oil content of paraffin wax which was developed for determining the percentage of oil in wax having a melting point of 105 F. or higher with not more than 10 per cent by weight of oil. The method involves dissolving the wax in methylethylketone, cooling to minus 25 F. to precipitate the wax, filtering out the methylethylketone containing the dissolved oil, and determining the oil content of this filtrate by evaporating the methylethylketone and weighing the residue.

The committee recommended for publication as information and for comment a test for saponification number of petroleum products by electrometric titration and also a proposed test for oxidation characteristics of steam-turbine oils based on extensive research investigations by a special section. In this latter method the oil sample is subjected to a temperature of 95 C. in the presence of water, oxygen, and an iron-copper catalyst, and the time required to build up a neutralization number of 2 in the sample is determined.

A number of changes were proposed in tentative standards to be incorporated immediately. In the Test for Knock Characteristics of Aviation Fuels (D 614 - 42 T) the minimum allowable air pressure is increased from 26 to 28 in. of mercury which change was based on tests conducted at the National Bureau of Stand-

ards. These showed that the knock rating of some types of fuels varied by nearly one octane unit per inch variation of air pressure.

The changes in the Test for Knock Characteristics of Motor Fuels (D 357 - 42 T) are largely editorial in nature and include a change in the guide curves in the portion above 90 octane number as a result of cooperative tests made by the Cooperative Fuel Research Committee.

Certain technical papers were of interest in the petroleum field including "A Method for Evaluating Performance in Service of Slow-Curing Asphalts" by Joseph Zapata, Wisconsin State Highway Commission, and "Accelerated Weathering of Bituminous Materials—Effect of Operating Variables" by Bruce Weetman, The Texas Company. Mr. Zapata concluded "field and laboratory evidence indicate that a heat test of the type described in A. S. T. M. Method D 243 - 28 T can be used for the evaluation of performance in service of slow-curing asphalts. The test can be used for control purposes by either specifying the time required to reduce the consistency of the asphalt from original to a consistency of either 100 or 150 penetration, or by specifying the consistency of the residue obtained after heating the asphalt for a given period of time."

Summarizing the results of tests on five roofing asphalts from different crude oil sources, Mr. Weetman concluded that "the temperature of test must be accurately controlled if comparable results are to be obtained between laboratories. It is recommended that 140 F. black bulb panel temperature be used as the best temperature to obtain values which will adequately differentiate between the weathering characteristics of different asphalts in the shortest practical time. The electrometric method for detecting failure of panels is essential for accurate results on those asphalts which fail by the formation of fine cracks or "pinpoints. Under normal conditions, amperage, refrigeration temperature, force of water washing, and surface cleanliness of the aluminum panels have no effect upon the test results."

Coal and Coke, Gaseous Fuels

An important contribution developed under the auspices of Committee D-5 on Coal and Coke was the new tentative test for determining the free swelling index of coal, results of which may be used as an indication of the coking characteristics of the coal when burned as a fuel. This small scale laboratory test is not designed to determine expansion of coals in coking ovens. However, the committee included in its report six proposed methods of test for determining the basic properties of coals and for evaluating expansion and pressure characteristics in coking ovens during carbonization. By publishing the methods the committee hopes to stimulate their greater use so that they can be more adequately evaluated. One method was the subject of a technical paper by Messrs. Soth and Russell on the subject "The Gieseler Method for Measurement of the Plastic Properties of Coking Coals."

The committee is including in its widely used Standard Methods of Laboratory Sampling and Analysis of Coal and Coke



G. J. Fink and W. V. Brumbaugh, National Lime Association; • J. D. Sullivan, Battelle Memorial Institute; J. D. Edwards, Aluminum Co. of America • C. F. W. Rys, Carnegie-Illinois Steel Corp.; E. W. Upham, Chrysler Corp.

(D 271 - 42) a statement indicating that a limit of 30 days should be set on the time between sampling and analysis of coal if the Btu. is an important consideration.

The Society's Committee D-3 on Gaseous Fuels reported important progress in phases of its work, including substantial agreement on a test for determining heating value of gases with a flow type calorimeter. The committee hopes to arrange publication of an extensive report covering work by the National Bureau of Standards on eleven specific gravity instruments for determining specific gravity and density of gaseous fuels.

Tests for Properties of Paper

Since its organization a few years ago, Committee D-6 on Paper and Paper Products has been concentrating its work on satisfactory methods of testing and has been cooperating closely with the Technical Association of the Pulp and Paper Industry (T.A.P.P.I.). At the annual meeting of the Society in Pittsburgh, six new test methods were approved. The following list indicates the applicability of these particular tentative standards.

Degree of Staining of Paper by Alkali (D 723 - 43 T)
Turpentine Test for Grease Resistance of Paper (D 722 - 43 T)
Wire and Felt Sides of Paper (D 725 - 43 T)
Surface Wettability of Paper (Angle-of-Contact Method) (D 724 - 43 T)
Kerosine Number of Roofing and Flooring Felt by the Vacuum Method (D 727 - 43 T)
Resistance of Paper to Passage of Air (D 726 - 43 T)

A number of other test procedures are being considered in the committee, including the following: Fiber composition, ply adhesion, wax pick test for surface strength, stretch of paper and paperboard, tensile breaking strength, wet tensile strength, erasing properties, edge tear, curl, stiffness, hydrogen ion concentration (unbuffered and neutral papers), gloss, and water absorption.

Several other methods are being completed which are now receiving study. In this group are the following proposed tests: Time of penetration by water of sized paper and paper products, measuring bursting strength, hydrogen ion concentration of paper extracts, determining the effect of heating on folding endurance, castor oil method for measuring printing oil penetration, and water vapor permeability.

Rubber Products

Throughout 1942-1943, Committee D-11 on Rubber Products has been very active, some indication of this being given by the four important new standards accepted at the annual meeting. These specifications and tests, which will be published for a year or more as tentative, cover the following:

Low-Temperature Brittleness of Rubber and Rubber-Like Materials (D 736 - 43 T)
Compressed Asbestos Sheet Packing (D 733 - 43 T)
Insulated Wire and Cable: Polyvinyl Insulating Compound (D 734 - 43 T)
Rubber and Synthetic Compounds for Automotive and Aeronautical Applications (D 735 - 43 T)

The test first listed is for use in evaluating the resistance to

freezing temperatures of rubber and synthetics used in automotive and aeronautical products. The use of motorized equipment in extremely cold climates by the Armed Forces and the increasing altitude of flight now being attained by airplanes have created many problems involving the resistance of materials to the extreme conditions which they must withstand. These problems are, of course, new and little work has been done in the past either on the properties of materials or on the methods of testing them under these extreme conditions. The new method determines the ability of compounds made from rubber or rubber-like materials to resist the effect of low temperatures in causing them to become brittle so as to fracture or crack when bent. Standard specimens are exposed to specified low temperatures for definite periods after which the specimens are bent in a prescribed manner and any fracture or cracking noted. The procedure is commonly called the "Thiokol" method.

The methods of testing compressed asbestos sheet packing give in the form of a consolidated standard a number of test procedures suitable for use in evaluating this material. Packing of this type is used for a variety of purposes but particularly as a gasketing material where severe services are encountered, such as those involving resistance to heat, heavy compression, or, in the case of synthetic packing, resistance to organic solvents. Large quantities of this material are now being used in aircraft engines and the need for standardized test methods has become even more urgent.

The specifications for insulated wire and cable, polyvinyl insulating compound, are very urgently needed to provide standardized requirements for a rubber substitute. Insulation compounds for electrical wires and cables made from polyvinyl chloride or from copolymers of vinyl chloride and vinyl acetate were in use to a limited extent prior to the war. In these compounds the vinyl plastics replaced natural rubber and gave properties superior for some purposes. Shortly after the outbreak of the war, all of the limited supply of these materials was reserved for the use of the Army and Navy. No standard specifications had been developed although there was a considerable background of service experience. The critical situation with respect to the supply of natural rubber now makes essential the fullest use of all available substitutes and with increased amounts of vinyl plastics becoming available through new plant construction, this material is being allocated more broadly for uses where it can replace rubber.

The new specifications for rubber and synthetic compounds for aeronautical and automotive applications cover vulcanized compounds of natural rubber, reclaimed rubber, synthetic rubber, or rubber-like materials, alone or in combination, which are intended for use in manufacturing various products. Compounds for tires, inner tubes, sponge rubber, and hard rubber are not included. The compounds listed are of two types grouped in four classifications based primarily on physical properties. Although the individual compounds provide a wide variety and range of physical properties, the specifications are general and are intended to furnish a basis for engineers to select material suitable for common applications. These new specifications have been based on simplification projects carried out in Technical Committee A on Automotive Rubber sponsored jointly by the A.S.T.M. and S.A.E.



Left: Two Old-Timers: F. N. Speller, Metallurgical Consultant, and H. E. Smith, Materials Engineer. Right: Wheeler P. Davey, The Pennsylvania State College.



J. G. Detwiler, The Texas Company

O. B. J. Fraser, International Nickel Co.; Marc Darrin, Mutual Chemical Co. of America.



At its meeting in Pittsburgh, Committee D-11 reviewed a number of phases of its work, including research work on low temperature which will include investigation of four types of tests, to cover (a) brittleness, (b) hardness and modulus, (c) loss of resilience, and (d) fatigue and flexing.

Two papers presented at the meeting in Pittsburgh were of distinct interest to the rubber field, one describing the use of the durometer for measuring hardness of rubber, in which the author, R. H. Taylor, National Bureau of Standards, described extensive work and outlined a recommended procedure. Also, he reported that if the durometer readings were plotted against the logarithm of the time, straight line curves were obtained, the slopes of which may be taken as a measure of creep. This paper is published in this BULLETIN—see page 25.

Another paper covered the relaxation of rubber-like materials in which a method was covered whereby each specimen is permanently fixed in its own test cell which can then be subjected to any desired conditions. Since the cells are inexpensive, it is practicable to test a large number of specimens over a long period.

New Work on Textiles

Committee D-13 recommended the approval of several new tentative standards, one covering, testing and tolerances for rope (leaf and bast fibers) (D 738 - 43 T); another provides testing procedure and tolerances for spun, twisted, or braided products made from flax, hemp, ramie, or mixtures thereof (D 739 - 43 T); and a third new test covers air permeability of textile fibers (D 737 - 43 T). This latter test essentially uses a suction fan for drawing air through a known area of fabric, a circular orifice over which the fabric to be tested can be clamped, a means for adjusting the pressure drop across the fabric to a known amount, and a means of measuring the volume of air flowing through the fabric.

Methods of testing and tolerances for yarns and threads made from flax, hemp, ramie, etc., are intended to apply to materials having breaking strengths up to 1200 lb.; nevertheless, it is understood that products sold as "rope" may be tested on machines described in these methods or by the conventional methods of rope manufacturers as may be agreed by the purchaser and the seller.

The new published standard covering testing and tolerances for rope gives definitions, tolerances, and describes procedures for sampling, circumference, determination of weight, breaking strength (both dry and wet), extractable matter, and analysis for protective treating materials.

Some additional definitions of terms relating to textiles were approved, a test for commercial weight of rayon staple was issued in revised form, and a number of other changes were made in various standards and tentative standards including the methods for identification of fibers in textiles. Four standards published previously as tentative are to be balloted upon by the Society membership for formal adoption. These cover Method of Test for Hard Scoured Wool in Wool in the Grease (Laboratory Scale Operations) (D 584); Testing and Tolerances for Woven Glass Tubular Sleeveing and Braids (D 581); Testing and Tolerances for Woven Glass Fabrics (D 579); and Testing and Tolerances for Woven glass Tapes (D 580).

In its report the committee listed a number of studies and investigations under way in all fields of its activities covering cotton, wool, rayon, asbestos, etc.

Water for Industrial Uses

SYMPOSIUM ON IDENTIFICATION OF WATER-FORMED DEPOSITS, SCALES, AND CORROSION PRODUCTS BY PHYSICO-CHEMICAL METHODS

A most interesting session for those concerned with the field of water for industrial use, including boiler feedwater and other types, was the third featuring two interesting papers on methods for determining dissolved oxygen and also the Symposium on Identification of Water-Formed Deposits. The session was under the sponsorship of Committee D-19 headed by Max Hecht, with R. E. Hall, secretary.

Messrs. Ulmer, Reynar, and Decker, The Detroit Edison Co., in describing the applicability of the Schwartz-Gurney method for determining dissolved oxygen and a modification of the method to make it especially applicable in the presence of such impurities as are encountered in power plants, pointed out that the Schwartz-Gurney method is used to get greater accuracy than with the regular Winkler method, but results are sometimes questionable when impurities are present. The modification they developed has given good results under plant conditions with no difficulties from reactions of impurities during fixation even when sulfite was present.

A very significant technical paper by Messrs. Adams, Barnett, and Keller, U. S. Naval Engineering Experiment Station, described field and laboratory determination of dissolved oxygen, the apparatus required, and the results of tests determining the accuracy of the methods. Since the Navy has need for two methods, a field method for use on shipboard and an accurate laboratory method for evaluation of deaerators during contract-acceptance and type-approval tests, very intensive work has been done to perfect the procedures. The methods described were calibrated and the errors either eliminated or evaluated. The authors indicated that the laboratory method will yield values of dissolved oxygen with a precision of 0.001 ppm. and within 0.002 ppm. of the true values. The field method will detect as little as 0.02 ppm. of dissolved oxygen and measure the concentration with an accuracy of about 0.02 ppm. Both methods have the order of accuracy for which they were intended, combined with great simplicity which several years of study and trial have accomplished.

The Symposium on the Identification of Water-Formed Deposits stressed the increased data secured when modern laboratory tests such as the X-ray, micro-analysis and other modern procedures are used. Three papers were included, one dealing with X-ray diffraction methods in the study of power plant deposits by Messrs. Imhoff and Burkhardt, Allis-Chalmers Manufacturing Co. The authors compared the diffraction analysis and chemical analysis of 22 deposits to show fundamental differences between the two methods. In addition, to compound identification, the method may give information concerning particle size, crystal modification, formation of solid solutions, and a rough quantitative estimation of the crystalline species present.

In a very cleverly prepared paper describing diagnosis of water problems at "Limbo" station (Limbo is the borderland of Hades) Messrs. Partridge, Scott, and Morrison, Hall Laboratories, Inc., detail constituents of deposits identified by optical properties and X-ray diffraction spectra. They gave a pertinent general summary that "Any inference from the preceding examples that the analytical laboratory may be closed up, once the necessary investment has been made in microscopic and X-ray equipment, is dead wrong. Chemical analysis still remains the reliable means of determining *how much* of various constituents a sample contains, while the other techniques are establishing *which* substances are actually present."

Messrs. Holmes and Walker, National Aluminate Corp., covered the interpretation of analyses and problems encountered in water deposits. They stated:

"The question usually brought up is whether there is any great value in determining the true identity of compounds in scale or, is the mere determination of the various radicals or elements present sufficient? In other words, if there is calcium, magnesium, silica, iron, or alumina present, what matters other than their elimination from the feedwater? If there are corrosion products, then eliminate the corrosion by properly treating the water. In general this may be true, but this is not sufficient for the cases where the cause of the deposit is not easily determined because all treating and operating conditions appear to be perfect. Furthermore these various elements are present as definite compounds, and, such being the case, it is the job of a good analyst to identify and report their exact composition and as far as possible their physical characteristics. If this is done, then there is a much better opportunity to determine not only the source of the various components but conditions under which they are formed"

Plastics

In addition to the annual report of Committee D-20 on Plastics, including four proposed new standards, there were several technical papers presented at the Society's Annual Meeting of definite interest in this field. These covered "Deformation Under Load of Rigid Plastics," by Robert Burns, Bell Telephone Labs., Inc.; "Impact Testing of Plastics—Energy Considerations," by David Telfair and Howard K. Nason, Monsanto Chemical Co.; and "The Relation Between Repeated Blow Impact Tests and Fatigue Tests" by William N. Findley, University of Illinois, and Otto E. Hintz, Radio Corporation of America.

The newly approved standards developed by Committee D-20 and published by the Society cover the following:

Spec. for Vinyl Chloride-Acetate Molding Compounds (D 728 - 43 T)
Spec. for Vinylidene Chloride Molding Compounds (D 729 - 43 T)
Test for Shear Strength of Plastics (D 732 - 43 T)
Measuring Relative Mobility of Thermosetting Molding Powder (Cup Method) (D 731 - 43 T)

The first named specification covers molding compounds consisting of vinyl chloride-acetate resins of approximately 86 per cent vinyl chloride content with the necessary lubricants, stabilizers, coloring, etc., and suitable for injection molding. They do not include special materials compounded for special applications.

The requirements for vinylidene chloride molding compounds apply to thermoplastic molding compounds and unoriented molded parts except pipe, composed of a copolymer of vinyl chloride and vinylidene chloride in the approximate ratio of 10 to 90, with suitable plasticizers, stabilizers, dyes, and pigments. The molding compounds are suitable for compression, injection, or extrusion molding.

The test for shear strength, on which work has been under way for some time, covers the punch type of test and is intended for use in determining the shear strength of test specimens of organic plastics in the form of sheets and molded disks in thicknesses from 0.0005 to 0.500 in.

The fourth item listed is designed to measure the mobility of thermosetting plastics under certain specified conditions of mold

design and applied temperature and pressure. This method can be used to determine batch-to-batch uniformity of a given plastic but cannot be used with certainty to determine whether different types of thermosetting materials are of the same mobility.

One item published in the annual report of the committee was withdrawn, namely, the proposed test for resistance of plastics to extreme service conditions. Later action on this is anticipated.

The committee plans to issue a revised edition of its special compilation of A.S.T.M. standards on plastics in the early fall, the first edition having been very favorably received—in fact it was exhausted a few weeks after publication.

In the annual report of the Society's Executive Committee, note was made of the outstanding work of Committee D-20 during the past year which involved the intensive development of 12 purchase specifications and various methods of test; also, the carrying out of considerable research work some of which has been reported in technical papers.

In their paper dealing with impact testing of plastics, Messrs. Telfair and Nason gave a detailed analysis of energy relations in the standard Izod and Charpy test methods which apparently accounts for some of the discrepancies in these tests. A modified test is described which measures the energy required to just initiate fracture in a test specimen. The results obtained by this modified test rank materials in the order of their known shock-resisting qualities, and correlate well with service experience.

The paper on repeated blow impact tests and fatigue tests described machines and various tests made on cellulose acetate. The authors observed that failure resulted from progressive fracture for both types of tests, and that the data for the stress and number of cycles, when plotted, showed close agreement between the two types of tests. This agreement indicates that the phenomenon of fracture after repeated impact is the same as that resulting from fatigue.

Recognition of Forty-Year Members

AT THE 1943 ANNUAL MEETING in Pittsburgh, there were awarded to eighteen members of the Society who have been members continuously for forty years a suitably engrossed certificate certifying to their continuous association with the Society. This interesting feature was established in 1938. That was the first year that such an award could be made since the Society was first established in 1898 as an American Section of the International Association for Testing Materials (now defunct). The growth of the Society was slow in the few years following 1898, but beginning with 1902-1903 and succeeding years there was a rapid increase. So at succeeding annual meetings there will be larger numbers whom the Executive Committee will be glad to welcome into this forty year class.

President H. J. Ball, Presiding Officer at the A.S.T.M. General Session on Wednesday evening, June 30, presented the current certificates to those members who were able to be at the meeting. A list of those who will have received certificates follows:

Frederick W. Bateman	National Lead Co.
The Carpenter Steel Co.	Pennsylvania State Highway Dept.
Almon H. Fuller	Henry H. Quimby
Harvey G. Kittredge	Charles Edward Skinner
Arthur D. Little, Inc.	Maximilian Toch
J. Strother Miller	Enrique Touceda
Rudolph Philip Miller	C. P. Van Gundy
Leon S. Moisseiff	Herman von Schrenk
Herbert F. Moore	L. W. Walter

Use and Misuse of the Salt Spray Test as Applied to Electrodeposited Metallic Finishes*

By C. H. Sample¹

THE BASIC FEATURE of salt spray testing, as the name implies, consists of exposing suitable specimens to a fog or mist formed by atomizing a solution of common salt. The test was originated by Capp² some twenty-nine years ago for the purpose of determining in an accelerated manner, the relative corrosion resistance of coatings intended for use in sea coast atmospheres. Since that time its use has been extended widely. From the point of view of the engineer concerned with finishing it would appear that now the test is considered by many specification writers as an all-purpose accelerated corrosion test with the implication that coatings which will pass this test are satisfactory, while those that will not are no good and should be rejected.

The introduction of the salt spray test to industry was occasioned largely by the incorporation of salt spray test requirements in various Government specifications in an effort to insure a quality of product capable of withstanding the relatively severe conditions of the Armed Services. Prior to the start of current world hostilities the test was undergoing a healthy but slow process of development. Its advantages and limitations were being investigated, its shortcomings resolved, and its usefulness extended where it was demonstrated this was justified. During this period it slowly gained many ardent supporters. However, it also experienced considerable opposition largely on account of the lack of uniform methods of operation and the failure to control important variables associated with the test, together with certain premature and erroneous predictions based on the results of the test. In the field of metal finishing there are many who even now question the ability of the test to yield reproducible results when applied to the wide variety of possible coating-basis metal combinations, and emphasize the lack of experimental evidence proving that satisfactory reproducibility can be obtained or that suitable correlation exists between salt spray test results and actual service behavior.

The relatively rapid and widespread conversion of industry to war production with the attendant increase in the use of those Government specifications containing salt spray test requirements has thus inadvertently forced a greatly increased use of a test which, in the considered opinion of many, is of doubtful merit. As a result the familiar old arguments for and against salt spray testing have come to the fore, misapplications of the salt spray test have been alleged, misinterpretations of the results have been frequent, and unfortunately, because of the general confusion, the production of important equipment has been impeded. It is the purpose of this paper to point out

the accepted uses and limitations of the salt spray test together with the pertinent factors which should be considered in establishing salt spray test requirement in specifications.

USES OF THE SALT SPRAY TEST

It is generally agreed that other things being equal the protective value of electropositive (cathodic) metallic coatings is a function of their thickness and an inverse function of their degree of porosity, while the protective value of electronegative (anodic) coatings is directly proportional to their thickness. Thus to the extent the salt spray test is capable of measuring these properties, it may be considered a measure of the protective value of metal coatings. The protective value of any particular coating, however, varies considerably with the environmental conditions to which it is exposed. Therefore, if the salt spray test is to be of value in determining whether or not any particular coating is suitable for any particular application, correlation of the test results with service performance must be established.

The incorporation of salt spray test requirements into A.S.T.M. Tentative Specifications A 166-41 T and B 142-41 T³ covering nickel-chromium and copper-nickel-chromium coatings on steel and zinc, respectively, is evidence that the test is considered of value by many for controlling the quality of these particular coating-basis metal combinations. In these cases, it will be observed, the test is used to reveal the continuity of the coatings, which are known to be electropositive to the basis metal in the presence of the salt solution. In regard to this use of the test, the corrodibility of the coating itself must be considered and in some instances the salt solution probably creates some pores which initially were only relatively thin spots. While this is important when the test is used as a laboratory tool in development work, it should not be a serious handicap to the test as an indicator of protective value when correlation between salt spray and service behavior has been established.

Other things being equal it will be obvious that the greater the potential difference between the coating and basis metal, *in the particular environment within the salt spray chamber*, the greater will be the corrosive action at the site of the discontinuity. Conversely as the potentials of the two metals approach each other in this atmosphere the action will be less, and the test will cease to perform its function when the potential difference is reversed. When the potentials are the same only relatively large discontinuities, for example those approaching the dimensions of actual bare spots, will be revealed.

It will be apparent that the test is not particularly suited for comparing directly the relative porosity of different coating-basis metal combinations unless the potential relations are the same. It may serve a useful purpose, however, for comparing the relative porosities of the same combinations, other things being equal.

³ 1942 Book of A.S.T.M. Standards, Part I, pp. 1374 and 1461.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication, or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia 2, Pa.

* Presented at the Forty-sixth Annual Meeting, Am. Soc. Testing Mats., Pittsburgh, Pa., June 28-July 1, 1943.

¹ Member of Technical Staff, Bell Telephone Laboratories, Inc., New York, N. Y.

² J. A. Capp, "A Rational Test for Metallic Protective Coatings," *Proceedings, Am. Soc. Testing Mats.*, Vol. XIV, Part II, p. 474 (1914).

When the potentials are reversed to a significant degree, as is the case of the electronegative coatings, the salt spray test may again be useful but in a different manner: that is, as a rough measure of the thickness or quantity of the coating applied. However, in view of the fact that quicker as well as more reliable methods for measuring the thickness of the common electronegative coatings are available^{4,5} the use of the salt spray test, primarily for this purpose, cannot be recommended. In the case of zinc coatings the relation between thickness of the coating and its salt spray life appears to be a straight-line function; however, this does not appear to be so in the case of cadmium deposits.⁶ Here again the test is most reliable when the same coating-basis metal combinations are compared and may be misleading for comparing different combinations.

The salt spray test can also be used to check possible deleterious effects of coupling dissimilar metals and the effectiveness of electrodeposited coatings in minimizing such action. In this connection it should be emphasized that the potential relationship of the coupled metals may change, depending on the environment to which they are exposed, and also that in the salt spray test an abundance of a strong electrolyte is present to promote the galvanic action. Hence here again correlation with actual exposure should be established before predictions based on salt spray test data are made.

With the establishment of suitable correlation with service conditions, the salt spray test may also be useful in judging the corrodibility of the coating itself. This factor in addition to the protection of the basis metal must be considered, for example, in the selection of suitable finishes for certain sensitive electrical and mechanical equipment. Correlation with service performance is particularly important in this connection, however, since the salt spray test provides continuous wetting of the surface while atmospheric exposure is generally intermittent. Hence the formation of protective films may take rather different courses in the salt spray and in the atmosphere.

LIMITATIONS OF THE SALT SPRAY TEST

The salt spray test has been referred to in the above as though it were completely standardized and prescribed, as well as performed in the same manner by everyone concerned. Unfortunately this is far from true, and in spite of several attempts toward standardization,^{7, 8, 9, 10} current methods of prescribing and conducting the test vary widely. For example, a recent inquiry conducted by the

Society's Committee B-8 on Electrodeposited Metallic Coatings revealed the following current operating conditions:

Solutions and the concentrations being used range from natural and synthetic sea water to saturated sodium chloride. Temperatures of operation vary from uncontrolled "room temperature" to 150 F. In the majority of cases, however, either the former or 95 F. is employed, the distribution between these two being approximately equal. Air pressures employed to atomize the solution range from 8 to 80 psi with no particular effort in most instances regularly to control the fog density other than as "heavy." The sizes of the test chambers employed vary from a few cubic feet to the dimensions of a small room. The positions of the specimens within the test box vary from the horizontal to the vertical, and the exposure periods range from 1 to 500 hr., depending largely on the purpose of the test, or the requirements of particular specifications.

Variations such as noted above, particularly in respect to temperature and the position of the specimens, which unfortunately are possible variations even though the test is performed in accordance with A.S.T.M. Tentative Method B 117 - 41 T, can account for the observed lack of reproducibility of salt spray test results and in a large measure are responsible for some of its severest criticism. On several occasions it has been observed that vertically suspended test panels were not uniformly wetted even after 200 hr. exposure while exposed horizontal surfaces were wetted almost immediately. Obviously this is a source of considerable variability, particularly when short exposure periods are involved. In this connection the testing of production items of complicated shapes demands particular attention in that certain surfaces may never be wetted while others are more or less drenched. It will be apparent that such specimens should be so placed that their critical or significant surfaces are freely exposed to the action of the spray and in the interest of reproducibility the positions should be the same in all cases. Little information is available in the literature in regard to the effect of operating variables as applied to electrodeposited coatings, excepting temperature.

Another limitation, particularly in reference to the use of the test for judging the quality of electrodeposited coatings, is the qualitateness of the results and in many cases the difficulty of defining a suitable end point. For example, if it has been established that for a coating to be satisfactory it shall completely protect the basis metal when exposed to the salt spray test for 200 hr., one could then require that there be no corrosion of the basis metal in the prescribed test within the prescribed period. This obviously means that in the case of electropositive finishes, the coating must in effect be completely continuous or nonporous; and in the case of electronegative finishes the coating must be of sufficient thickness to give cathodic protection to the basis metal for the prescribed time.

If on the other hand experience has shown that complete continuity of electropositive coatings is not required, which is known to be the case in many instances, the problem of describing a degree of corrosion which can be tolerated presents itself. This is one of the greatest weaknesses of the salt spray test for specification use. Shortening the period of exposure is by no means a solution to the problem because in the case of electropositive coatings the

⁴ Abner Brenner, "Magnetic Method for Measuring the Thickness of Nonmagnetic Coatings on Iron and Steel," *Journal of Research*, Nat. Bureau Standards, Vol. 20, No. 3, March, 1938, p. 357.

⁵ Abner Brenner, "Dropping Tests for Measuring the Thickness of Zinc and Cadmium Coatings on Steel," *Journal of Research*, Nat. Bureau Standards, Vol. 23, No. 3, September, 1939, p. 387.

⁶ William Blum, Paul W. C. Strausser, and Abner Brenner, "Corrosion-Protective Value of Electrodeposited Zinc and Cadmium Coatings on Steel," *Journal of Research*, Nat. Bureau Standards, Vol. 16, No. 2, February, 1936, p. 185.

⁷ E. H. Dix, Jr., and J. J. Bowman, "Salt Spray Testing," Symposium on Corrosion Testing Procedures, p. 57, Chicago Regional Meeting, Am. Soc. Testing Mats. (1937). (Symposium issued as separate publication.)

⁸ W. H. Mutchler, R. W. Buzzard and Paul W. C. Strausser, "Salt Spray Test," *Circular Letter 530*, Nat. Bureau Standards, July 1, 1938.

⁹ "Process for Salt Spray Corrosion Test," Army-Navy Aeronautical Specification AN-QQ-S-91 (December 12, 1938).

¹⁰ Tentative Method of Salt Spray Testing of Non-Ferrous Metals (B 117 - 41 T), 1941 Supplement to Book of A.S.T.M. Standards, Part I, p. 566.

period for the first appearance of basis metal corrosion is primarily a function of the effective size rather than the number of pores. Thus a very useful coating with a single large pore may be rejected whereas a relatively inferior coating with a large number of very fine pores would be acceptable. In the A.S.T.M. Specifications A 166 and B 142, previously referred to this limitation is circumvented with reasonable success by requiring that there be no appreciable corrosion, within a specified time. Appreciable is then defined, for example, as the presence of more than six corrosion spots per square foot or any spots larger than $\frac{1}{16}$ in. in diameter. Difficulties have occurred in interpreting this requirement as applied to small piece parts, for example, those of less than 24 sq. in. However, it would appear that this difficulty could be easily resolved and is only mentioned here for the sake of illustration.

Another limitation of the salt spray test results from the lack of fundamental knowledge regarding the behavior of different coating-basis metal combinations under the conditions of the test, particularly in regard to the magnitude of the potential relationships between the two metals. In the use of the test for indicating resistance to corrosion, this factor of course becomes relatively unimportant when correlation between salt spray and service behavior is established. Its importance is great, however, when there is an attempt to predict service behavior from salt spray data in the absence of such correlation. It cannot be too strongly emphasized that the salt spray test merely shows the corrosion behavior of coatings and materials when exposed to the conditions which exist *within the test chamber*, and any correlation of this with service behavior can only be established with certainty by actual test of each combination. There is an apparent lack of such data, particularly in regard to the behavior of electrodeposited coatings intended for indoor use.

FACTORS TO BE CONSIDERED IN REGARD TO SPECIFICATIONS

One of the primary factors to be considered before any test is incorporated in a specification as a basis for acceptance or rejection is whether or not the test is capable of yielding reproducible results, especially when performed at different times and by different people. This is particularly true for accelerated corrosion tests of which the salt spray test is a notable example.

Having established the suitability of the test from the standpoint of its reproducibility, an equally important factor to be considered is whether or not the result obtained is a true measure of the factor it is intended to control. That is, for example, in regard to electrodeposited coatings, is there suitable correlation between the test results and service performance? Without such correlation, the test is useless. In this connection reasonably good correlation has been reported between salt spray and outdoor exposure tests of nickel coatings for varying thicknesses on steel.^{11, 12} That is, increased corrosion protection is obtained in both cases by increasing the thickness

(decreasing the porosity) of the coating. Correlation has not been satisfactory, however, when nickel and nickel plus chromium coatings of the same general thickness are compared.^{12, 13}

When satisfactory correlation with service has been established and reproducibility of the test is accomplished, the maximum service requirements of the finish should be considered in relation to the cost and practicability of obtaining such a coating.

Among other things to be decided in this connection is the relative importance of *appearance* of the finished article, involving the corrosion resistance of the coating itself *versus* the corrosion *protection of the basis metal*, including the degree of protection required. The former of course involves the latter but the reverse is not always true. It will be apparent that decisions on the above factors should include consideration of the expected or desired length of life of the finished article and the environmental conditions to which it will be exposed. In this respect and particularly in cases where the parts to be finished are components of a more elaborate structure, due consideration should be given to apparatus or equipment of which the finished article forms a part.

An example of the apparent disregard of this factor is a certain restricted specification in widespread use which required that "... the plating on all plated parts shall be" among other things "capable of withstanding . . . a period of 200 hr." in the salt spray test at 35 C. "without evidence of rust, corrosion or other deleterious manifestations." While this probably could be attained the need for such stringent requirements is questionable, in view of the type of equipment covered by the specification. It is probable that the literal interpretation of the requirement does not convey the real intent of the specification. If such is the case it also illustrates the need for definite knowledge regarding the minimum requirements acceptable and the necessity for care in defining the end point of the test.

CONCLUSIONS

1. The salt spray test cannot be recommended as a quality test for electronegative type coatings.
2. When thoroughly standardized and properly conducted the salt spray test is frequently useful in evaluating the degree of porosity of electrodeposited metallic coatings of the electropositive type.
3. The time of exposure to the salt spray required to reveal a certain degree of porosity varies with the coating-basis metal combination being tested and should be correlated with actual exposure tests.
4. The time required for "first rust" to appear is not as important as the appearance of the coating after a given length of time in the salt spray.
5. Further standardization of A.S.T.M. Tentative Method B 117 - 41 T in order to reduce the number of variations permissible seems advisable at this time. Also the individual user of the salt spray box must put forth a much more conscientious effort to standardize his equipment and his exposure technique.
6. The lack of experimental data correlating salt spray and service behavior of the wide variety of coating-basis metal combinations would indicate that except for revealing particularly inferior coatings the test does not merit its current extensive use in specifications.

(Discussion on next page)

¹¹ Paul W. C. Strausser, Abner Brenner, and William Blum, "Accelerated Tests of Nickel and Chromium Plating on Steel," *Journal of Research*, Nat. Bureau Standards, Vol. 13, No. 4, October, 1934, p. 519.

¹² C. E. Heussner, "Comparison of Salt Spray and Ocean Spray Testing," *Proceedings of Educational Sessions*, Am. Electroplaters' Soc. June 8-9, 1942, p. 75.

¹³ G. A. Lux, and M. Berdick, "Effect of Polishing Base Metals Upon the Protective Value of Electroplated Coatings," *Proceedings of Educational Sessions*, Am. Electroplaters' Soc., June 8-9, 1942, p. 19.

[EDITOR'S NOTE.—The following remarks by Mr. Sample were made in presenting his paper at the meeting and include some supplementary data to the paper.]

MR. C. H. SAMPLE.—I realize the salt spray test is a very controversial subject and I want to make it clear it is not my intention to be destructive in my criticism of it. Also, I have nothing new to contribute in the way of experimental results which might prove or disprove the value of the test. In this sense my remarks might be construed as not being very helpful and one might ask, then just why was the paper written. The answer to that question is essentially this. It appeared that the importance of the salt spray test for evaluating the suitability of electrodeposited coatings was being very much overemphasized. Furthermore it appeared that in some instances this false importance had reached such proportions that it was impeding the design and manufacture of important equipment. For example, in several instances that have come to my attention, the specifications require that the plating on all plated parts shall be capable of withstanding 200-hr. exposure in the salt spray test "without evidence of rust, corrosion or other deleterious manifestations." I should like to emphasize that this requirement applies to all plated parts. It will be apparent that even the relatively insignificant components of the laboratory structures covered by this specification are included in this requirement. Also, this requirement applies to the finishes on relatively corrosion resistant materials, which would of themselves exhibit a satisfactory, useful life without any finish whatsoever. Again this requirement holds even though in some instances the equipment is housed within a waterproof gasketed enclosure.

Of course these criticisms cannot properly be directed at the salt spray test *per se*, but rather at the lack of sufficient consideration of all the factors involved, particularly in regard to the wording of the requirements in the specification.

On the other hand, it is generally agreed, the salt spray test can be a very useful tool for evaluating the suitability of certain electrodeposited coatings, when, of course, it is properly operated and controlled, and when the results are interpreted in the light of the limitations of the

tests. In this paper I have attempted to point out (to a limited extent) what appeared to me to be proper uses and some limitations of the test together with pertinent facts which should be considered in using the test in specification. It is hoped the paper will promote the proper use of the test and at the same time curb the trend toward what appears to me to be misapplications. It is further hoped that the paper will stimulate some active research aimed toward determining the effect of operating variables on the results of the test, and the correlation of test results with service exposure. That there is need for work in this connection is borne out by the lack of experimental evidence in the literature. The lack is noteworthy particularly in regard to indoor exposures, that is, indoor exposures of the type to which communication and other electrical equipment will be exposed. In regard to the apparent lack of experimental data I recently had the opportunity to review an extensive bibliography on salt spray testing. This bibliography covered articles published during the last 19 yr. There were only 10 of these that dealt specifically with metallic coatings and only one of these was concerned with indoor type of exposures.

The principal conclusions drawn from the paper are as follows:

Since thickness measurements are a better measure of the protective value of electronegative coatings and since quick and reliable methods for measuring thickness are available the salt spray test cannot be recommended as a quality test for such finishes.

On the other hand, when thoroughly standardized and properly conducted, the salt spray test is of value for revealing the quality of electropositive type metallic coatings.

Also, it is concluded that in the interest of reproducibility it would appear desirable to further standardize A.S.T.M. Tentative Method B 117 - 41 T in order to reduce the number of permissible variations.

And finally the lack of experimental data correlating salt spray and service behavior of the wide variety of the coating-basis metal combinations would indicate that, except for revealing particularly inferior coatings, the test does not merit its current extensive use in specifications.

DISCUSSION

MR. SAM TOUR.¹—As Chairman of the Society's Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys and as the Society's tentative method for the salt spray test is under the jurisdiction of Committee B-3, it seems that I should make some comment on this paper on the "Use and Misuse of the Salt Spray Test as Applied to Electrodeposited Metallic Finishes."

It is certainly true that there are numerous variables in the salt spray test. I question, however, whether it is desirable to so standardize a test that everything is tested in precisely the same manner at precisely the same temperature, with precisely the same solution, for the same number of hours and viewed with the same pair of eyes, and laid in the same position in the test. Service condi-

tions are not that standard. It seems to me that any test should be designed in accord with the service intended for the part. If the part is a part of irregular shape and section it is impossible to put it in a test box and have it in a horizontal or vertical position. It will be in all its characteristic positions according to the shape of the part. We should not test flat panels, and say that the result is applicable to a curvilinear surface. We should test the material itself and not some substitute for it made to suit some particular peculiar test conditions. The salt spray test set up by Committee B-3 permits the use of whatever material is to be tested in the test box without specifying that it must be flat, horizontal, vertical, or at some particular angle. The same is true with respect to the solution. Some prefer to determine corrosion resistance to sea water which is around 3 to 4 per cent salt while others prefer 20 per cent sodium chloride solution.

¹ Sam Tour & Co., Inc., New York, N. Y.

For direct marine exposure service, a test should be permitted that uses marine water and not 20 per cent sodium chloride, and *vice versa*.

There has been a considerable amount of work done on the question of temperature. Mr. Heussner published a paper some years ago which showed the variation in rate of attack in salt spray at different temperatures. I doubt if it is necessary to specify that every laboratory use the same temperature. It may not be convenient to use the same temperature in the North as in the South and tropical zones. Ninety-five degrees may be satisfactory at some places—every now and then it does get hotter than 95 F. in some places, but I doubt if we should specify 140 F. either. If it is known that the test results vary with temperature, and account can be taken of temperature, why restrict the test? The test can be standardized and yet can be varied, controllably, to suit the particular material being tested.

It is true that there are specifications for materials which specify unreasonable requirements. It is possible to find specifications that call for a 200-hr. salt spray test on items that are never to be exposed to salt atmosphere. That is no fault of the salt spray test; it is an error on the part of the man who wrote the specifications.

There are many places where the requirements for material used in a machine are higher than what is really necessary. In these days when we are redesigning matériel to make use of less strategic metals we find many cases where the designer originally went down some list and picked out the gold-plated articles because they looked good. Often we can get along with much less expensive and what might be said to be a lower quality metal, yet of adequate quality for the service. Instead of complaining about the salt spray test *per se*, we should complain about the specifications which specify excessive salt spray test resistance.

There are some specifications with regard to finishes on steel which call for only 16-hr. salt spray resistance. That certainly is the other extreme from the 200-hr. test that is referred to in this paper. Resistance for 16 hr. in the ordinary salt spray box is very little resistance. If more corrosion protection than that is not required, it should not be necessary to go to the extremes in standardizing the salt spray box.

The paper contains the rather positive statement that the salt spray test is not applicable to such coatings as, for example, zinc on steel. It is true that we can measure the thickness of a zinc coating on steel. However, to measure the thickness in every spot over the entire surface is very difficult. If the salt spray test is a test which will pick out nonuniformity and do it more quickly or more efficiently than a thickness measuring gage, then certainly the salt spray test is the test to use. That is the way the salt spray test is being used on quite a number of zinc-plated articles. Although theoretically the salt spray test may not be applicable where we have sacrificial metal coatings, practically it is a useful tool.

MR. F. L. LAQUE.²—I find myself in rather serious disagreement with Mr. Tour's remarks questioning the wisdom of standardizing the conditions under which the salt spray

test should be conducted. I gathered that Mr. Tour considered the possibility of so conducting a test in a salt spray box as to reproduce some condition likely to be encountered in the practical use of the materials in which we are interested. I am inclined to doubt that there are many cases where we are interested in the performance of materials under the exact conditions that ordinarily exist within a salt spray box. I am pretty firmly convinced that there would be only a coincidental relationship between performance in the salt spray box and performance in the ocean, which I think would dispense with the requirement that sea water be used instead of sodium chloride or that 4 per cent sodium chloride be used instead of 20 per cent. I am also firmly convinced that the salt spray test is purely an arbitrary test and if it is an arbitrary test, why not make it arbitrary in a uniform and standard way?

MR. C. E. HEUSSNER.³ I should like to go along with Mr. Tour's suggestion that we cannot standardize the salt spray test for all production applications. The salt spray test should be standardized as a control tool based upon comparative test data. We use the salt spray test in checking for porosity of metallic electrodeposits of nickel. This test helps us to determine shop procedure, base metal cleaning, and pores in the deposit. Since these are production parts, it would be impossible to determine the angle at which the part is tested. On coatings such as cadmium and zinc, we use the salt spray as a continuity test to tell us whether we have complete coverage of the base metal. The lack of this coverage is usually due to poor cleaning, and not entire removal of scale, and this is readily detected by the salt spray.

The remark is made that many articles are not used at sea, so why use the salt spray? It should be remembered, however, that a great volume of electroplated articles are used at the seashore and seawater corrosion is severe. So on such applications, it might be well to substitute sea water for the 20 per cent salt solution and in some cases elevate the temperature of operation. These things again should be very carefully checked with controls. It is our belief that the salt spray is a very beneficial tool in segregating a great portion of the inferior quality of electrodeposited coatings—meaning by this, all parts that show corrosion in the salt spray are unsatisfactory when used but not necessarily meaning that all parts that are satisfactory in the salt spray will be a quality deposit.

MR. E. A. ANDERSON.⁴—There is one phase of this general subject of salt spray testing which I think is worth emphasizing, as a word of caution.

Mr. Sample has pointed out that in his search for information, for positive published data, he has found very little. There is a real need for adequate data on which to settle many of these controversial opinions. I will say that in preface to the point that I wish to make.

If we assume, and it can only be an assumption until proof is obtained, that the order in which samples of the same type—to distinguish from comparisons between different types—fall as to quality in a salt spray test will be the same order in which they fall in service, we may find ourselves sadly misled.

² Metallurgist, Development and Research Div., The International Nickel Co., Inc., New York, N. Y.

³ Materials Engineer, Chrysler Corp., Detroit, Mich.

⁴ New Jersey Zinc Co. (of Pa.), Palmerton, Pa.

I brought with me some old data obtained at a time when no attempt was made to standardize salt spray tests, so we cannot place too much reliance on them, but the figures fall something like this:

On three lots of plated materials, all of the same thickness range, the lives on an outdoor exposure to the first appearance of the first corrosion blisters were 12 months, 12 months, and 1 month. The hours of salt spray from companion samples of the same lots were 112 hr., 104 hr., and 111 hr.

Now in that particular case if the salt spray test had been the criterion for acceptance, on production, lot No. 3, which had only one-twelfth of the service life of lots Nos. 1 and 2, would have been accepted.

I am not offering that as an objection to the salt spray test but as a warning that there is a real need for correlation studies between service and salt spray to avoid the possibility that we may be misleading ourselves in believing that high salt spray values necessarily mean good service life. There may be possibilities of reversals.

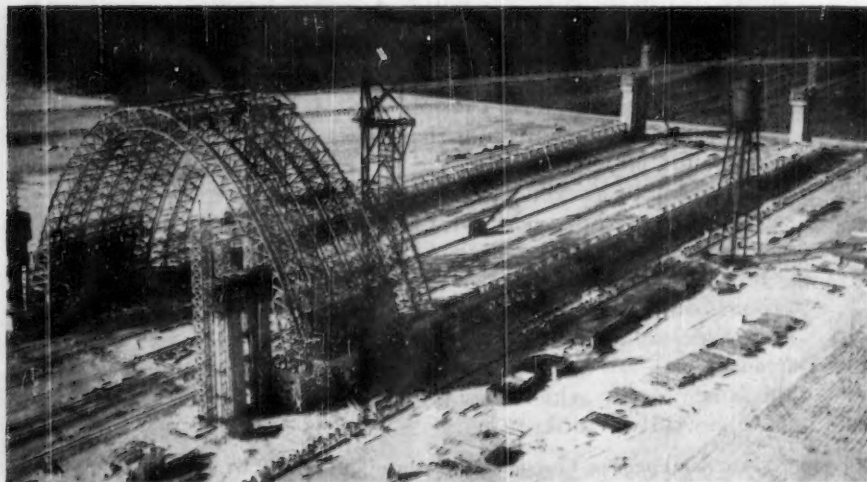
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The accompanying illustrations show a most notable use of fireproof lumber construction used by the Navy in its blimp hangars which are catenary-shaped arch buildings, 1058.5 by 297 ft. in overall plan dimensions. In these hangars it was mandatory that the treated material pass a fire test described by the Navy specifications in accordance with the Tentative Method of Test for Fire-Retardant Properties of Wood (C 160-41 T) of the American Society for Testing Materials.

Foundation of hangar with a portion of the arches in place. The structure will be 1000 ft. long and 153 ft. high.
Official U. S. Navy Photograph—Cut courtesy Wood Preserving News, American Wood-Preservers' Association.



MR. SAMPLE (*author's closure*)⁵.—In closing I would like to thank the discussers for their remarks. Also I can say that in general I concur with most of the comments made.

In regard to standardization of the test I agree with Mr. Tour to the extent that it is impracticable in a general specification to specify the particular angle at which the variety of production items should be placed in the salt spray box. However, it seems practicable and desirable to me that any particular item being manufactured and tested by different suppliers be tested in a uniform standard manner by everyone concerned.

In addition to the use of the test for evaluating the finishes on production items, it should be emphasized it is also widely used as a laboratory research tool in the development of protective coatings. In the latter use complete standardization would appear particularly desirable in the interest of reproducibility.

⁵ Member of Technical Staff, Bell Telephone Laboratories, Inc., New York, N. Y.



The timber arches spring from rigid concrete frames and were erected in segments by the traveler. The space beneath frames is enclosed for orifices.

Official U. S. Navy Photograph—Cut courtesy Wood Preserving News, American Wood-Preservers' Association.

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Use of the Shore Durometer for Measuring the Hardness of Synthetic and Natural Rubbers*

By Rolla H. Taylor¹

SYNOPSIS

The manner in which the readings of the Shore durometer vary with time was studied for 16 different compounds of natural and synthetic rubbers. The data were obtained from motion pictures showing a durometer and a stop watch in the same field of view. To eliminate the personal factor the durometer was mounted in a frame and pressure was applied by dead-weight loading. The results indicate both the necessity and the practicability of specifying that measurements be taken at a definite time after the application of the durometer to the specimen. The results also indicate the possibility of using readings taken at two different times as a rough measure of the relative creep of different rubbers.

TWO RECENT developments have focused attention on the Shore durometer for measuring the hardness of rubber. On the one hand, the Shore durometer readings have been made a requirement of many purchase specifications so that where they were for many years regarded as approximate values used principally for descriptive purposes, they have now become a basis for the acceptance or rejection of large deliveries of rubber goods. On the other hand, most of the synthetic rubbers now coming into large scale use show more creep than natural rubber, and this creep greatly increases the uncertainty and variation of the readings of the durometer as it is commonly used. On some synthetic rubber compounds examined at the National Bureau of Standards, the decay of the durometer reading was as much as 15 units in the first minute. The Columbian Carbon Co. reported a decay of the same order of magnitude for Buna S.² On account of the importance of this factor, tests have been made to show the change of Shore durometer readings with time for a series of natural and synthetic rubber compounds covering the range over which the instrument is commonly used. It is hoped that the results of these tests, together with the well-known work of Larrick³ on the standardization of the durometer, will form the basis of a more definite specification for the use of the durometer in the determination of hardness.

APPARATUS

The apparatus shown in Fig. 1 consisted essentially of a calibrated Shore durometer, type A, meeting A.S.T.M.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia 2, Pa.

* Presented at the Forty-sixth Annual Meeting, Am. Soc. Testing Mats., Pittsburgh, Pa., June 28–July 1, 1943.

¹ Associate Rubber Technologist, National Bureau of Standards, Washington, D. C.

² "Shore Creep—A New Measure of Loginess. The Carbon Reinforcement of Buna S (GR-S)," *Columbian Colloidal Carbons*, Columbian Carbon Co., New York, N. Y., Vol. IV, p. 31 (1943).

³ Lewis Larrick, "The Standardization of Durometers," *Proceedings, Am. Soc. Testing Mats.*, Vol. 40, p. 1239 (1940).

requirements,⁴ a stop watch mounted side by side in a frame, and a hand-operated motion picture camera. The frame was designed to hold the base plate of the durometer parallel to the base of the frame, and to permit only vertical motion of the durometer. This arrangement allowed the durometer to be applied to the specimen quickly and permitted the load on the durometer to be varied. From one to four weights of 0.5 lb. each were slipped on the vertical shaft to which the durometer was fastened. The number of these weights used for each test was the minimum required to insure firm contact between the test specimen and the base plate of the durometer.

The photographic record of the time and the durometer reading was projected on a screen by means of an enlarger. A subdivided scale was made to fit the projected image of the durometer, and with its aid the position of the pointer could be read to 0.1 unit ($\frac{1}{10}$ of the smallest graduation). The corresponding time could be read to 0.1 sec. from the image of the watch. The personal element was eliminated in so far as possible. The durometer was always applied to the specimen in the same manner and the constant pressure of the base plate of the durometer on the specimen throughout any one test eliminated any error which might result from a nonuniform pressure such as may occur during hand applications lasting longer than a few seconds. Furthermore, slight tipping of the durometer was rendered impossible. Trial applications made by hand indicated that a slight tipping of the durometer may cause a perceptible change in the reading, and may, therefore, be quite important when close tolerances are specified.

Certain limitations of accuracy arose from the non-uniform motion of the second hand of the stop watch and from the lack of synchronism between the application of

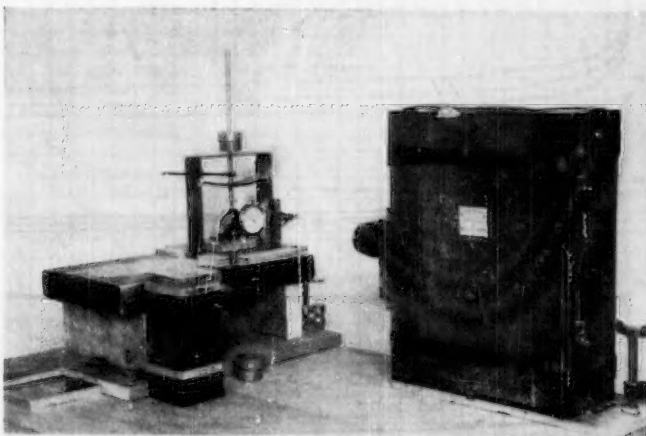


Fig. 1.—Camera Setup to Take Simultaneous Pictures of Durometer and Stop Watch.

⁴ A.S.T.M. Tentative Method of Test for Indentation of Rubber by Means of the Durometer (D 676 – 42 T), 1942 Book of A.S.T.M. Standards, Part III, p. 1334.

TABLE I.—COMPOSITION OF COMPOUNDS TESTED.

Ingredients, Parts by Weight																		Conditions of Vulcanizations		
Formula	Blended Smoked Sheet	Buna S	Buna SW ^a	Perbunan	Butyl B 145 ^b	Thiokol F.1A	Castilloa	Zinc Oxide ^c	Stearic Acid	Agarite Powder ^d	Dibutyl Phthalate	Soft Carbon Black	Channel Black	Tunds ^e	Altax ^f	Diphenyl Guanidine	Captax ^g			Sulfur	Time, min.	Steam Pressure, psi.
No. 1	100	...	...	...	...	...	...	5	1	...	...	...	...	...	1	...	...	3	30	40
No. 2	100	...	...	...	...	...	...	5	1	...	...	50	...	...	1	...	...	3	30	40
No. 3	100	...	...	...	...	...	...	5	1	1	...	...	50	...	1	...	...	3	30	40
No. 4	...	100	...	...	...	...	...	5	1	...	...	...	...	...	1.5	...	...	3	30	40
No. 5	...	100	...	...	...	...	...	3	1	...	...	50	50	...	1.5	...	...	2	30	43
No. 6	125	...	...	...	...	5	0.5	...	...	50	...	...	1.5	0.25	...	2.55	20	43
No. 7	...	100	...	...	...	...	...	3	1	...	...	...	90	...	1.5	...	...	2	30	43
No. 8	...	100	...	...	...	...	...	3	1	...	5	50	...	...	1.5	...	...	2	30	43
No. 9	100	...	...	...	5	1	...	...	...	50	...	1	...	...	2	30	40
No. 10	100	...	...	...	5	1	...	40	...	50	...	1	...	...	2	30	40
No. 11	100	...	...	5	3	...	...	...	...	1	...	...	0.5	1.5	45	65
No. 12	100	...	...	5	3	...	...	50	...	1	...	...	...	1.5	45	65
No. 13	100	...	...	5	3	...	...	...	50	...	...	...	0.5	1.5	40	65
No. 14	100	...	10	0.5	...	...	...	...	...	0.3	0.1	...	...	20	50
No. 15	100	...	10	0.5	...	...	50	...	...	0.3	0.1	...	...	30	50
No. 16	100	6	4	...	...	...	...	...	...	...	0.5	3.5	65	40

^a Buna SW contains 100 parts by weight of Buna S and 25 of Naftolen.

^b The zinc oxide and sulfur shown for compound No. 12 were added by the manufacturer. Compounds Nos. 11 and 13 were made from the pure polymer.

^c Kadox variety of zinc oxide was used for all compounds except No. 12 in which the zinc oxide was added by the manufacturer, and No. 16 in which XX-Red 72 was used.

^d Phenyl beta naphthylamine.

^e Tetramethyl thiuram disulfide.

^f Benzothiazyl disulfide.

^g Mercaptobenzothiazole.

the durometer and the camera. These causes led to possible errors of the order of 0.1 sec. in the time of reading and sometimes resulted in failure to obtain a picture of the maximum reading of the durometer. The error in reading the time is negligible after the first 2 or 3 sec.

Another possible source of error was the additional pressure caused by the inertia of the durometer and weights

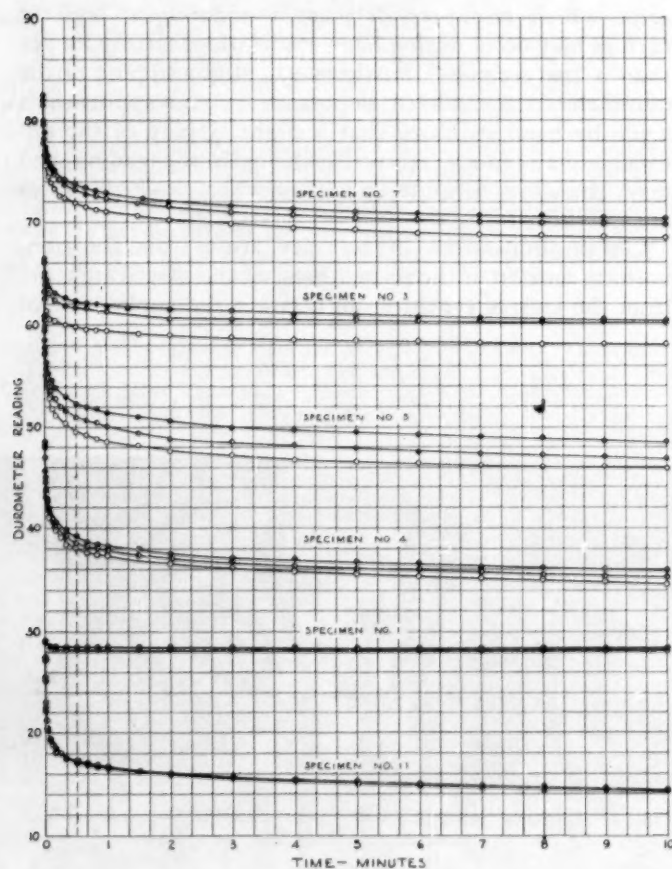


Fig. 2.—The Relation of Shore Durometer Readings to Time. Three successive tests are shown for each specimen. Compounds of the specimens are given in Table I.

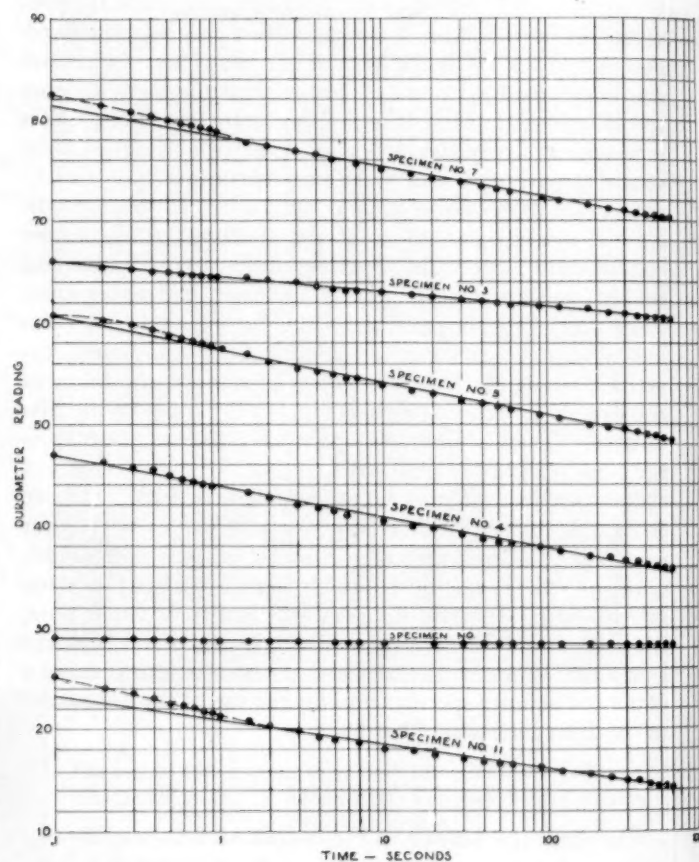


Fig. 3.—The Relation of Durometer Readings to the Logarithm of Time.

during application. As indicated by Fig. 3, however, these errors were not great and apparently had no influence beyond the first 1.5 or 2 sec.

The exactness of the results as a whole is indicated by the conformity of the individual points to a smooth curve in practically every case and by the reproducibility of the successive tests made on the same specimen under similar conditions, as will be shown later.

TEST SPECIMENS

The test specimens were made from five different types of synthetic rubber and two kinds of natural rubber and were designed to cover the range of hardness for which the Shore durometer is commonly used. The formulas of the 16 different compounds are shown in Table I. The optimum time of vulcanization was determined for each compound in the usual way. Specimens were then vulcanized to the optimum cure in the form of square slabs 0.5 by 3 by 3 in. in dimensions.

Although considerable care was exercised to obtain homogeneous specimens, hard spots such as have frequently been observed with certain types of compounds⁵ were present in some cases. The existence of these was shown by measurements not here reported. They were observed particularly in specimen No. 3.

METHODS OF TESTS

The specimen to be tested was placed on the base of the frame and the weights on the vertical shaft were adjusted to give the desired load on the durometer. The durometer was then lowered until the indenter just touched the specimen. The stop watch and camera were then started and the durometer was released and permitted to drop the length of the indenter or approximately 0.1 in. onto the specimen. A continuous record of about 10 frames per sec. was taken for the first 10 sec. and subsequent records of 3 or 4 frames each at 15, 20, 25, 30, 40, and 50 sec., and at 1, 1.5, 2, 3, 4, 5, 6, 7, 8, 9, and 10 min. after the application of the durometer.

The tests were made in constant temperature rooms at ambient temperatures of 100, 78, and 35 F., respectively. The actual temperatures at the surfaces of the specimens were somewhat higher on account of radiation from the lamp used for illumination.

On the basis of data collected with the durometer mounted as described above, the following method was set up for all measurements taken by hand application:

1. Hold the durometer in the recommended manner⁴ in the right hand with the indenter just touching the specimen and with the right wrist or forearm resting on the specimen or its support. Hold a watch in the left hand.
2. Make several trial applications to determine the minimum force required to seat the durometer on the specimen.
3. At the desired time apply the durometer as quickly as possible with the minimum required pressure, being careful to maintain constant pressure throughout the test and also being careful to hold the durometer motionless.
4. Take readings at 3, 5, 30, and 50 sec. after the application of the durometer to the specimen.

The readings taken at 30 sec. were used as a measure of the hardness and the readings taken at all four times were used in determining creep.

RESULTS OF TESTS

Relation of Durometer Readings to Time:

The curves showing the durometer readings as a function

⁵ J. H. Howey, "Hard Spots in Vulcanized Rubber Compounds," *Industrial and Engineering Chemistry*, Vol. 23, pp. 287-290 (1931); see also, A. R. Kemp, F. S. Malm, G. G. Winspear, and B. Stiratelli, "Diffusion of Sulphur in Rubber," *Industrial and Engineering Chemistry*, Vol. 32, pp. 1075-1084 (1940).

of time all exhibit a rapid decrease of the readings during the first few seconds with less and less change for succeeding intervals of time. Typical curves for different types of natural and synthetic rubber of widely different hardness are given in Fig. 2, and are numbered in accordance with the formulas in Table I. Although the curves are all of the same general form, the amount of decay with time varies a great deal from one compound to another. The three curves for each sample represent three successive runs.

Curves of the form shown in Fig. 2 indicate the magnitude of the creep but do not lend themselves well to evaluating creep quantitatively. If, however, the durometer readings are plotted against the logarithm of the time in seconds, as in Fig. 3, curves are obtained which may be represented approximately by straight lines. The slopes of these straight lines afford a simple numerical measure of the creep of the different samples, as will be discussed below. The actual observations, as indicated by the points, show two small but consistent departures from a linear relation. During the first 1.5 sec. the points fall above the straight line on account of the inertia of the durometer and its loading weights when they are dropped the length of the indenter onto the specimen. After the effect of this initial disturbance has disappeared the points deviate from a straight line by a very slight but consistent concavity upward. After the first 1.5 sec., however, no reading was more than 0.3 unit off the straight line.

Effect of Temperature on Durometer Readings:

The foregoing tests were all made in a constant temperature room at 78 F. In order to determine the effect of variations in temperature all 16 of the compounds described in Table I were also tested in rooms maintained at 100 F. and 35 F. The actual temperatures of the samples were probably somewhat higher on account of the radiation from the lamp used to illuminate the durometer and the stop watch.

Typical curves are given in Fig. 4 showing the change in durometer readings with time at the three temperatures. For each of the compounds shown in this figure the

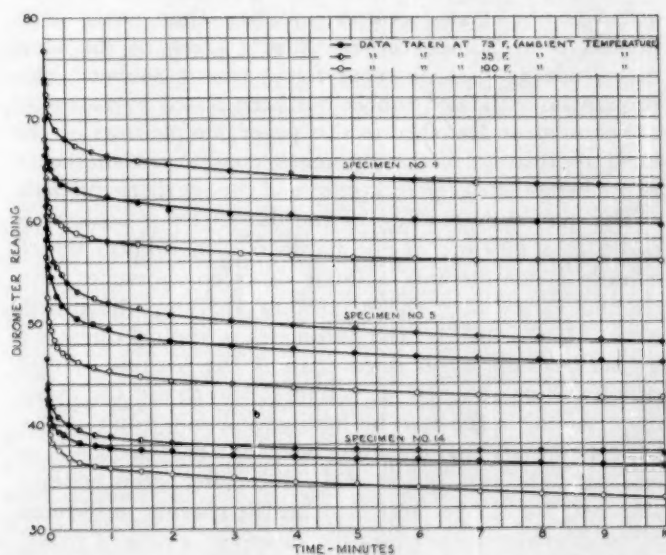


Fig. 4.—The Effect of Temperature on Durometer Readings with Relation to Time.

TABLE II.—COMPARATIVE READINGS OF SHORE DUROMETER TAKEN BY SIX DIFFERENT OBSERVERS AT 30 SEC. AFTER APPLICATION.

Specimen	Observer A	Observer B	Observer C	Observer D	Observer E	Observer F	Mean	Mean Deviation
No. 1	30.0	32.0	30.0	30.5	30.0	30.5	30.5	0.5
No. 2	46.0	45.5	45.5	47.0	45.0	47.0	46.0	0.7
No. 3	64.0	66.0	65.5	65.0	65.0	66.0	65.3	0.6
No. 4	41.0	41.0	39.5	39.0	40.0	41.0	40.3	0.7
No. 5	53.5	54.0	53.0	55.0	52.5	52.0	53.3	0.8
No. 6	52.0	55.0	52.0	52.5	50.0	50.0	51.9	1.3
No. 7	77.0	76.0	76.5	76.0	77.0	76.0	76.4	0.4
No. 8	42.0	42.5	41.5	41.5	40.0	40.0	41.3	0.8
No. 9	66.0	67.0	66.5	66.5	65.5	64.0	65.9	0.8
No. 10	45.5	46.0	47.0	46.5	47.5	46.0	46.4	0.6
No. 11	18.5	19.0	19.0	18.0	18.5	18.0	18.5	0.3
No. 12	41.5	42.0	40.0	43.5	42.5	40.0	41.6	1.1
No. 13	45.0	45.0	43.5	45.0	45.5	44.0	44.7	0.6
No. 14	40.0	40.5	40.5	40.0	41.0	40.0	40.3	0.3
No. 15	51.5	52.0	49.0	50.5	51.0	50.0	50.7	0.8
No. 16	30.5	32.5	32.0	31.5	30.5	32.0	31.5	0.7

durometer readings are lower, the higher the temperature. The difference in the durometer readings after 30 sec. for compound No. 5 was 7 units for a change in room temperature from 35 F. to 100 F. For the same temperature interval, compound No. 9 showed a difference of 8 units. Other synthetic rubber compounds likewise showed relatively large temperature effects, particularly when carbon black was employed as a filler. Comparable compounds of natural rubber, on the other hand, showed differences of only 2 or 3 units between measurements made at 35 F. and at 100 F. Since this difference is of about the same magnitude as variations between different parts of the same sample it is not particularly significant, and for this reason no illustrative curves for natural rubber are included in Fig. 4. The systematic differences between the three curves for the same sample, as shown in Fig. 2, is attributed mainly to change in the temperature of the specimens during the test.

DISCUSSION OF RESULTS

Use of the Durometer for Measuring Hardness:

Figure 2 shows at a glance that if the Shore durometer is to be used for obtaining reproducible measurements of the hardness of rubber it is necessary to make the reading at a definite time after the application of the instrument. The error introduced by failing to take time into account may not be large for some compounds of natural rubber, but for synthetic compounds it will, in general, be quite significant. Difficulties which have been called to our attention by manufacturers indicate that some compounds of reclaimed rubber show a creep of the same magnitude as that observed for synthetic rubbers. Although no reclaimed rubber has been tested by means of the equipment described in this paper, simple tests by the hand application of the durometer confirm the similarity in the behavior of the reclaimed and the synthetic rubbers.

The maximum reading of the durometer is sometimes taken as a measure of the hardness. In rubbers which exhibit a considerable amount of creep, however, this reading varies with the manner of applying the instrument. If the load on the durometer is applied quickly a higher reading is obtained than if the load is applied slowly. Consequently, it is impractical to use the maximum reading as the basis for hardness measurements. Similarly, to specify that a reading be made a few seconds (5 or less) after the application of the durometer seems undesirable because of the large error in the reading introduced by small errors in the time. If, however, a time of 30 sec. is specified, neither variations in the rate of application of the durometer nor small errors in timing have much effect.

It may be seen from Fig. 2 that even for a compound showing a large creep an error of 5 sec. in estimating the time interval of 30 sec. would result in an error of less than plus or minus one unit.

The tests made at different temperatures, as shown in Fig. 3, indicate the importance of controlling not only the method of using the durometer but also the temperature if the readings are to be obtained to small tolerance.

As a practical test of the method given earlier for the hand application of the durometer, six different observers were instructed to follow that method explicitly in taking durometer readings of the 16 specimens used in this investigation. Some of the observers were familiar with the durometer and others were using it for the first time. The results, which are shown in Table II, represent only one measurement on each specimen by each observer.

The maximum difference between readings made on the same specimen by any two observers was found to be 5 units. On 14 of the 16 specimens, the difference was 3 units or less. The mean deviation from the mean of the readings by the six observers ranged from 0.3 to 1.3 units. This deviation represented not only the differences in the use of the Shore instrument but also real differences between different areas in the same test specimen. Inasmuch as the latter differences amounted to as much as 3 units for some specimens, the agreement among the different observers was considered to be good, especially in view of the fact that each observer made only one reading on a specimen.

In order to determine the consistency of observation made at intervals other than 30 sec., tests were conducted in which the durometer was applied by hand and readings were taken at the maximum indication of the pointer and at intervals of 3, 5, 30, and 50 sec. after application. As before, measurements were made by different observers on all 16 specimens. The mean deviation from the mean of all observations in each set was as follows:

	Shore Units
Maximum reading.....	1.48
3-sec. reading.....	0.78
5-sec. reading.....	0.74
30-sec. reading.....	0.69
50-sec. reading.....	0.68

These results indicate that the maximum reading of the durometer cannot be determined with anything like as great precision as the reading at intervals of 3 sec. or longer. The precision of the reading is improved somewhat as the interval is lengthened from 3 sec. to 50 sec., but the improvement at the longer intervals is not conspicuous. The interval of 30 sec. is recommended for practical use so that the timing can be done by means of the second hand of an ordinary watch without exercising special care.

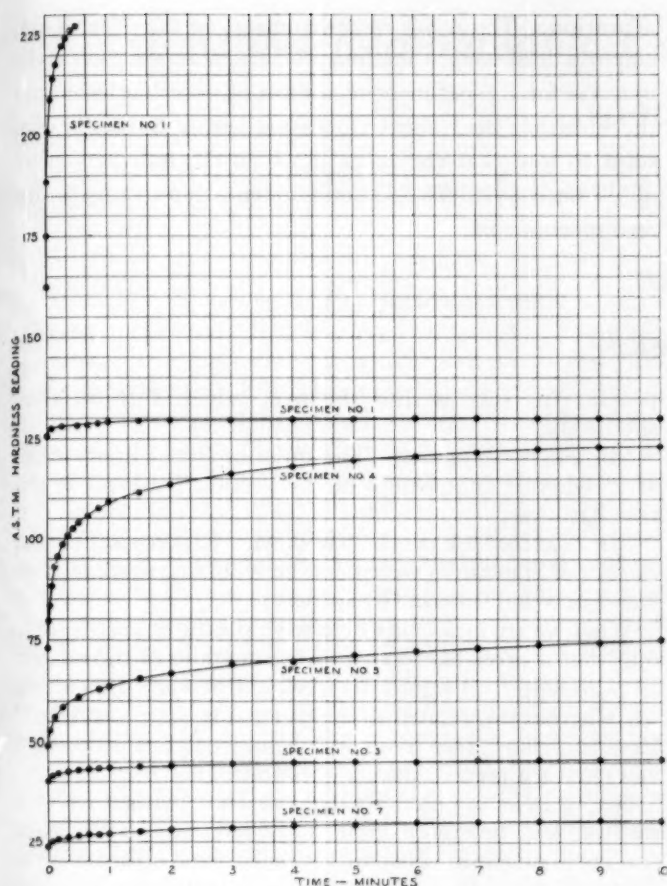


Fig. 5.—The Relation of Readings of A.S.T.M. Hardness Tester to Time.

Use of Durometer for Measuring Creep:

The results shown in Fig. 3 indicate that with photographic recording the durometer can be employed to obtain a reasonably precise measurement of creep. If, however, the instrument is to be of practical use for measuring creep it must be applied by hand and the readings taken visually.

From the observations taken at 3, 5, 30, and 50 sec., the slope of the curve relating the durometer reading to the logarithm of the time was obtained for each specimen tested. The results of measurements by the six different observers are compared in Table III with the values of the slopes determined from curves such as those shown in Fig. 3.

TABLE III.—COMPARISON OF MEASUREMENTS OF CREEP DETERMINED BY HAND APPLICATION OF THE DUROMETER WITH THOSE DETERMINED FROM CURVES

(The slope of the curves obtained by plotting durometer readings as a function of the logarithm of time in seconds is taken as the creep.)

Specimen	Creep (Shore Units)							
	From Curve	From Observer						Mean
No. 1	0.2	0.5	0.0	0.5	0.0	1.0	1.0	0.5
No. 2	0.7	1.0	2.0	0.7	1.5	1.5	1.5	1.4
No. 3	1.5	1.5	2.2	1.5	2.5	2.0	2.0	1.9
No. 4	3.1	3.3	4.0	3.5	4.0	5.0	5.5	4.2
No. 5	3.3	4.2	5.5	4.0	3.7	4.2	5.0	4.4
No. 6	2.9	2.5	3.5	3.0	3.0	4.2	2.5	3.1
No. 7	3.0	3.0	3.5	3.5	3.2	4.2	4.0	3.6
No. 8	2.7	2.5	3.7	4.2	3.2	3.2	3.5	3.4
No. 9	2.5	3.0	3.2	3.0	3.5	3.7	5.0	3.6
No. 10	2.9	3.2	4.0	3.7	4.0	3.5	5.0	3.9
No. 11	2.3	2.5	3.0	2.7	3.5	3.0	2.5	2.9
No. 12	3.4	3.7	5.0	4.2	4.5	5.0	4.5	4.5
No. 13	3.7	4.0	5.2	6.5	4.5	4.7	4.5	4.9
No. 14	1.8	2.0	2.5	2.2	2.5	3.2	2.5	2.5
No. 15	2.9	2.7	4.5	4.0	4.7	4.7	3.5	4.0
No. 16	0.2	0.5	0.5	1.2	0.5	0.2	0.5	0.6

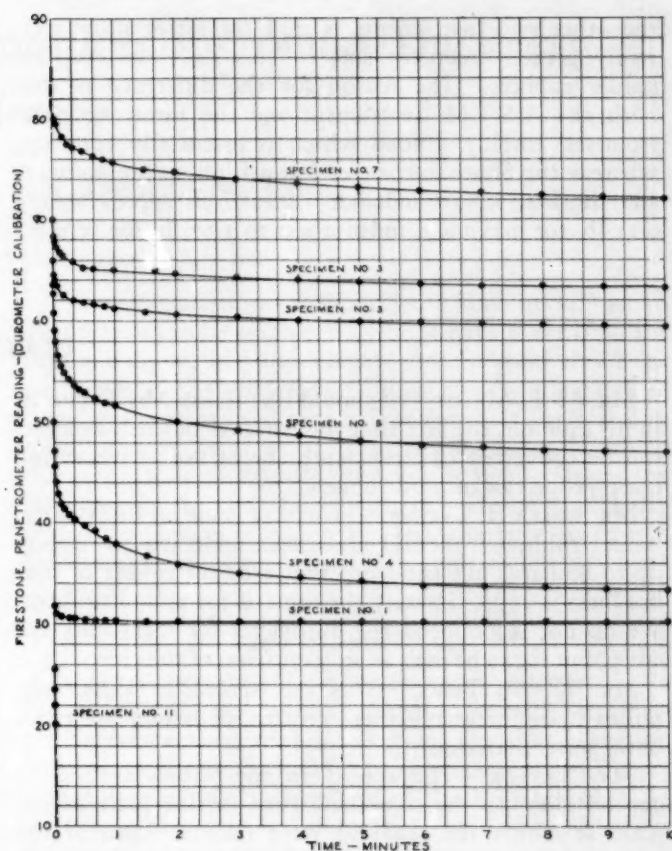


Fig. 6.—Relation of Readings of a Firestone Penetrometer to Time.

The results given in the table indicate that the durometer can be employed to make a useful though not precise measurement of the creep in rubber. The measurements by the different observers show a relatively large scatter and the average values of the slopes are somewhat higher than those obtained from the curves based on photographic records. The results, however, do show clearly the increasingly greater creep in a series consisting of a pure gum compound, a compound containing soft carbon black, and a compound containing channel black, respectively. The results also bring out the greater creep exhibited by most synthetic rubber compounds as compared with corresponding compounds of natural rubber.

APPENDIX

Advantage was taken of the photographic setup for the foregoing investigation to make similar records of the relation of hardness readings to time for the A.S.T.M. hardness tester and for a Firestone penetrometer which had been calibrated to read in Shore durometer units. The results of typical tests with these two instruments are shown in Figs. 5 and 6. The curves are numbered in accordance with the specimens, the composition of which is given in Table I. Both instruments, like the Shore durometer, show a rapid change in readings immediately after application. The rate of change decreases with time, and when the readings are plotted against the logarithm of the time an approximately linear relation is obtained.

The chief difference between the Shore durometer and

the other two instruments is that the latter show relatively greater creep for soft rubbers and less creep for harder rubbers. The reason for the difference is that both the A.S.T.M. instrument and the Firestone penetrometer employ a load which is essentially constant, whereas the Shore durometer has a high spring constant and the load on its indenter varies from approximately 0.11 lb. for maximum indentation to 1.87 lb. for zero in-

dentation. The A.S.T.M. instrument, on the other hand, employs dead-weight loading with the same weight on the indenter for all specimens regardless of their hardness, and the Firestone instrument employs a spring having a constant so low that the actual load on the indenter varies only from 0.95 lb. for maximum indentation to 1.05 lb. for zero indentation.

DISCUSSION

MR. M. L. MACHT.¹—I should like to ask Mr. Taylor if, in his opinion, the fact that the readings of the durometer can be converted to creep might be of use in measuring creep properties of hard rubbers.

MR. ROLLA H. TAYLOR.²—We have made no study of the harder rubbers. We did make measurements on rubbers up to 90 hard, but the creep indicated for rubber of that hardness is approximately the same as for the soft rubber. We do not recommend the durometer for measuring the creep, but it can be used as an indication of the creep.

MR. R. M. BERG.³—Was the spread in values obtained by different observers greater for harder materials or for softer materials?

MR. TAYLOR.—The spread in the values seemed to depend more on the compound than on the place of the scale at which the readings were taken. Some of the rubbers, particularly a natural rubber compound with considerable carbon black, showed hard spots, and we had buna-S compounds in which there was considerable variation but we have no explanation for that.

MR. A. W. CARPENTER.⁴—There has been a question raised concerning the difficulty of holding a hand instrument steady and uniform in position for 30 sec., watching a stop watch at the same time. Mr. Taylor's data, I think, quite clearly show that his observers, at least, did not encounter any great difficulty in that respect.

Mr. Taylor's data also show conclusively that the worst possible reading that can be taken, as far as error and deviation are concerned, is the maximum reading—the immediate reading. That point, particularly, is of great interest.

MR. A. J. KEARFOTT.⁵—Would it not be possible to mount the stop watch on top of the durometer, in that way leaving one hand free?

MR. TAYLOR.—I suggested that the stop watch be held in the left hand principally because you can hold it there where you can see it and look at the durometer at the same time.

The principal thing is to have any kind of clock which will indicate seconds. You do not need a stop watch.

If you take readings at 30 sec. \pm 5 sec., you will not be very far off. I have specified them closer than that because if you specify 5 sec., somebody is going to read them at ten and if you specify them at one, then maybe

people will stay within the five, which I think they should do.

MR. H. H. BASHORE.⁶—The question arises in my mind as to whether that would be the average hardness or the true hardness.

MR. TAYLOR.—I think that if Mr. Tuckerman, of the Bureau of Standards, were here, he would have some comments on what is meant by hardness.

What we are measuring here with the durometer is some unit that is probably related to the modulus of the rubber. It is an empirical figure, so it would be very difficult to say whether it is related to the true hardness. You would have to define "true hardness" before you could do that, and that is a pretty difficult question.

But you can say that the reading that you get by this method will be reproducible, provided the conditions of test are maintained constantly as they are specified.

MR. MYRON PARK DAVIS.⁷—I should like to ask Mr. Taylor how many different instruments were used in making these tests. Did he use only one instrument, or was he able to get the same results from two or three different instruments?

What trouble was experienced in calibration of the instruments and how long would they hold this calibration after once calibrated?

MR. TAYLOR.—One instrument was used throughout the test. However, that instrument was calibrated carefully both before, during, and after the test.

We have one other instrument available and when the two instruments are in good calibration, the results are comparable. I did not include comparative results in the report but it is very necessary that each instrument used be calibrated.

No particular difficulty was experienced in calibrating our instruments. However we do have to check their calibration at intervals depending on the frequency and severity of use.

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Symposium on Spectroscopy and Spectrochemical Analysis

UNDER THE AUSPICES of the Optical Society of America there will be held in Pittsburgh October 7 to 9, inclusive, Symposia on Spectroscopy and Spectrochemical Analysis. These technical sessions are being arranged in place of the M.I.T. and Mid-West Spectroscopy Conferences which have been held in previous years. A.S.T.M. members who are interested can obtain further details by contacting Prof. A. C. Hardy, Massachusetts Institute of Technology, Cambridge, Mass.

Estimating Radiographic Exposures for Multi-Thickness Specimens¹

By Herman E. Seemann² and George M. Corney¹

TWO GENERAL PROBLEMS must be considered in the production of every radiograph. These are: first, the exposing technique which pertains to the selection of a suitable kilovoltage and exposure as well as good geometrical relations, and, second, the photographic process, the object of which is to render the various intensities visible as a permanent record on film. The exposing technique is relatively simple if the specimen is a plate of more or less uniform thickness but becomes more complicated if several thicknesses are to be penetrated simultaneously. Satisfactory radiographic rendition of the various parts of the specimen may be the result of a combination of factors which the operator has selected from previous experience, or even by a lucky guess. The resulting visibility of penetrameters or other details may appear adequate for the purpose, but how can one be sure that the best possible radiograph has been produced? The answer to this question is that *quantitative information must be applied to both the exposing and photographic phases of the work in order to insure the best result.*

Graphs showing the relation between metal thickness and exposure for various kilovoltages, or for gamma rays, are in common use. These are adequate for application to the radiography of uniform plates but can serve only as rough guides for irregular castings or other articles having considerable variation in section. If, however, an additional graph is available, namely, the "characteristic curve" of the X-ray film, suitable radiographic exposure conditions for multi-thickness specimens may readily be selected. The exposure chart gives the exposure-thickness relationship, while the characteristic curve of the film gives the photographic density-exposure relationship. From the two curves, the density to be expected in the radiograph for any or all of the various metal thicknesses in the specimen may be predicted with reasonable accuracy. For example, if the maximum density that can be used in conjunction with a given illuminator is known, it is possible to calculate beforehand the factors which will produce a radiograph suited to the local viewing conditions.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication, or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia 2, Pa.

¹ Presented before the Society's Committee E-7 on Radiographic Testing, at the Forty-sixth Annual Meeting, of the American Society for Testing Materials, Pittsburgh, Pa., June 28, 1943. After this paper was written, the authors were privileged to read the manuscript of a paper entitled "The Sensitometric Estimation of Radiographic Exposures" by G. F. G. Knipe, of the Research Laboratory, Kodak Limited, which will be published in the *Photographic Journal*. The similarity of the two papers is, however, coincidental.

Another paper bearing on the subject which was published after completion of this manuscript is "A Method for Compiling an Accurate X-ray Technique Chart," by J. J. Allen, Jr., *Industrial Radiography*, Vol. 1, No. 4, April, 1943, p. 51.

² Physicist, Kodak Research Laboratories, Eastman Kodak Co., Rochester, N. Y.

The characteristic curve of an X-ray film not only yields data which can be combined usefully with those from the exposure curve, but also valuable information about the properties of the film itself. Films may be compared in speed and contrast and thus judged for their applicability to different types of work. The density range in which the contrast is practically constant is readily found by inspection of the characteristic curve. Hence, familiarity with calculations based on the characteristic curve is a definite asset in making the radiographic technique an exact procedure.

THE EXPOSURE CHART

In its most common form, an exposure chart resembles Fig. 1. Such charts cannot be used, in general, for different X-ray machines without applying suitable correction factors. A simple method for preparing an exposure chart is to make a series of radiographs of a built-up pile of plates consisting of a number of steps. This "step tablet" is radiographed at several different exposure times at each of a number of kilovoltages. The exposed films should all be processed under identical conditions and according to the procedure which will later be used for routine work. Each radiograph will consist of a series of photographic densities corresponding to the X-ray intensities transmitted by the different metal thicknesses. (Photographic

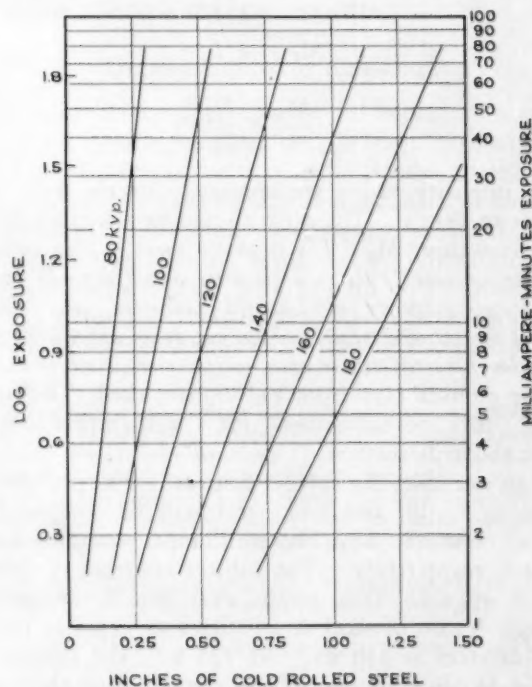


Fig. 1.—Typical Exposure Chart for Steel.

It is based on the use of Type K film with lead-foil screens for a density of 1.0 at a focus-film distance of 40 in. Development was in Kodak X-ray Developer for 5 min. at 68 F.

density is defined as $\log_{10} I_0/I$, where I_0 is the light intensity incident on the film and I is the light intensity transmitted by the film. It is measured by a special type of photometer called a "densitometer.") A certain density, for example, 1.5, is selected as the basis for preparation of the chart. Wherever this density occurs on the step-tablet radiographs, there are corresponding values of thickness, milliamperere-minutes, and kilovoltage. It is unlikely that many of the radiographs will contain a value of exactly 1.5 in density, but the correct thickness for this density will be found by interpolation between steps. Thickness and milliamperere-minute values are plotted for the different kilovoltages in the manner shown in Fig. 1.

Notice that thickness is laid off on a linear scale while milliamperere-minutes are on a logarithmic scale. The logarithmic scale is not necessary but is very convenient since it compresses an otherwise long scale and also simplifies the procedure which is the subject of this discussion.

It is apparent that the milliamperere-minutes required to produce a given density at a given kilovoltage are inversely proportional to the corresponding X-ray intensities transmitted by the specimen. Mathematically stated, this is, $M = k/I$, where M is milliamperere-minutes, I is the intensity, and k is a constant, the value of which depends on the kind of units in which I is expressed. If the intensity is called "reciprocal milliamperere-minutes," k is unity in the equation. In radiography, the ratio of intensities is much more important than any one value of intensity so that a unit of intensity is seldom required. When dealing with two intensities, I_1 and I_2 , transmitted by different parts of a specimen, this equation is written

$$M_1 = \frac{k}{I_1} \text{ and } M_2 = \frac{k}{I_2}$$

Dividing M_1 by M_2 ,

$$\frac{M_1}{M_2} = \frac{k/I_1}{k/I_2}$$

or

$$\frac{M_1}{M_2} = \frac{I_2}{I_1}$$

Thus, intensity ratios are obtained directly from charts similar to Fig. 1. The ratio should be taken so that M_1 is greater than M_2 . The intensity ratio is then called the "subject contrast." It is a quantity which depends upon the kilovoltage, intensity of scattered radiation, and thickness range of the material penetrated but not, to an appreciable degree, upon film characteristics or upon milliamperes, time, or distance. (If the gamma rays from radium are used, "milligram-hours" may be substituted for "milliamperere-minutes" in the above discussion.)

As an example, the subject contrast for a specimen consisting of $3/4$ -in. and 1-in. steel will be computed (see Fig. 1). At 180 kv., the milliamperere-minutes are 1.8 and 4.8, respectively. The subject contrast is therefore $4.8/1.8 = 2.7$. This means that the X-ray intensity through $3/4$ in. of steel is 2.7 times as great as through 1 in. of steel at 180 kv. At 140 kv., the subject contrast is $39.0/9.6 = 4.1$. Thus, the exposure chart alone shows that the subject contrast is greater at the lower kilovoltage without any reference to appearances in a radiograph or to characteristics of the X-ray film.

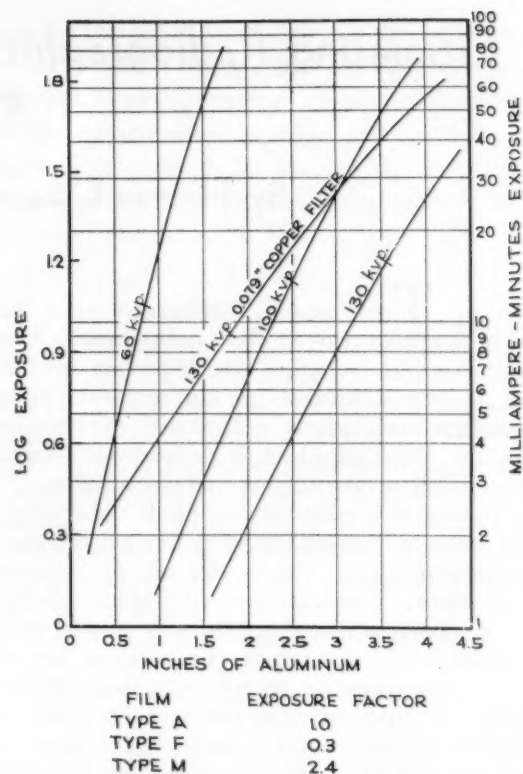


Fig. 2.—Abridged Exposure Chart for Aluminum.

Slope of the log exposure-thickness curve is noticeably affected by radiation quality. Conditions were: Focus-film distance, 40 in.; density, 0.8; development, in Kodalk X-ray Developer for 5 min. at 68 F.

Figure 2 is an exposure chart for aluminum, with only four curves shown for convenience of illustration. Note that the slope of the 130-kv. line for a 0.079-in. copper filter is less than that of the 130-kv. line without filtration. Hence, changing radiation quality by filtration, as well as by raising kilovoltage, reduces subject contrast and gives an additional feature of exposing technique to be considered in the radiography of multi-thickness specimens.

THE CHARACTERISTIC CURVE OF X-RAY FILM

The characteristic curve of a photographic material is sometimes called the H. and D. curve after Hurter and Driffield who, in 1890, first used a plot of density versus log exposure. Application of this graph to the study of film properties has become almost universal because so much valuable information can be derived from it. It also makes possible the interpretation of densities in terms of the radiation intensities which made the radiograph or, conversely, the prediction of densities from known intensities. Familiarity with the characteristic curve of X-ray films is helpful in selecting the best film for a given purpose. The important features of this curve will be discussed in the next few paragraphs as an introduction to the subject and to facilitate the combined use of exposure charts and characteristic curves for the estimation of radiographic exposures of multi-thickness specimens.

Curve ABCD in Fig. 3 is the characteristic curve of a film exposed to direct X-rays. The ordinate scale is photographic density. The abscissa scale is the logarithm to the base 10 (common logarithm) of the relative exposure. The logarithm is taken rather than the quantity itself

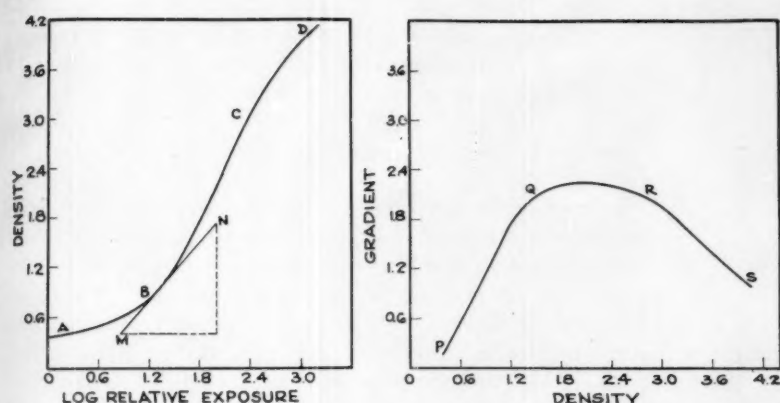


Fig. 3.—Typical Direct X-ray Characteristic Curve (Density versus Log Exposure) of an X-ray Film and the Gradient versus Density Curve Derived from It.

partly because it compresses a long linear scale and also because analysis of the curve is thereby simplified. Exposure is the product of intensity and time or $E = It$, for example, milliamperes-minutes. Kilovoltage, distance, and filtration remain constant. As a matter of convenience, milliamperes are also usually maintained constant so that the data are obtained by exposing a film for a series of known times. With direct or lead-screen exposures, the result is the same as if the intensity were varied in the same way.³ The convenience and reliability of varying time rather than intensity are apparent to any X-ray worker. There are no particular time values which should be used, but plotting of the data is simplified if exposure values are the same distance apart on the logarithmic scale. For example, if the series is composed of 1, 2, 4, 8, 16, . . . time units, the logarithms are approximately 0, 0.3, 0.6, 0.9, 1.2, . . . respectively. It is convenient therefore to choose a series in which the ratio of any two consecutive exposures is constant (a geometrical progression).

The slope of the tangent MN is the "gradient" G . Since it changes from point to point, it is necessary, in giving the value of the gradient, to specify the density at which it was evaluated. Gradient is one of the quantitative expressions for "film contrast." If the gradient has a large average value over the range BC, the film is said to have high contrast. Most common photographic films, when exposed to light, show a well-defined straight-line portion between B and C. The slope of this straight line is called "gamma" but, since the curves for X-ray films seldom straighten out within the range of usable densities, they have no significant gamma. For practical purposes, the slope of the straight line joining two points at the limits of the most useful part of the curve is a good measure of film contrast and is called "average gradient." In the region AB, commonly called the "toe" of the curve, the gradient is too low to be of much radiographic value. A given percentage intensity change does not yield so great a density difference on the film in this region as in the region BC. This is the reason why a minimum density for radiographs is often specified, not because there is any virtue in a particular density but because the gradient above that den-

sity is sufficient for good rendition of detail. In fact, gradient is a very useful concept and deserves just as much consideration as factors of technique. The gradient begins to diminish in section CD, the "shoulder," so that detail begins to disappear no matter how much light is available to penetrate the high densities. For most X-ray films, the shoulder starts at densities that are too high to be utilized in practice. The maximum brightness of the illuminator then becomes the factor which limits the usefulness of the high-density region.

The curve PQRS in Fig. 3 is a plot of gradient values versus density obtained from the characteristic curve ABCD. The procedure consists in drawing tangents, such as MN, at enough different densities so that when the slopes of the tangents are plotted against densities a smooth curve is obtained. Since the gradient is a maximum at $D = 2.1$, this film will show detail best at this density with sufficient illumination. If the illumination is inadequate, lower densities at correspondingly lower contrasts must be used. Gradient values are a measure of a film's ability to show detail, assuming constant conditions of film graininess and focal-spot geometry.

DETERMINATION OF EXPOSURES

The most direct approach to an explanation of the method for determining the radiographic exposure for a specimen of varying section is to study an example. It is assumed that a radiograph is to be made of an aluminum casting, the maximum and minimum thicknesses of which are 2.5 and 1.0 in., respectively. Calculations are based on the use of Type A film⁴ with no densities below 0.8.⁵ It is further assumed that no densities above 3.0 are useful because of the limitations of the particular il-

⁴ The X-ray films mentioned in this paper may be described briefly as follows: All of these films, except Type F, are designed primarily for direct X-ray or lead-screen exposures.

Type A—A fine-grain, high-contrast film of low speed.

Type F—A film providing high contrast and speed when used with calcium tungstate intensifying screens. Low contrast is available when this film is exposed to direct X-rays, to gamma rays, or to lead-screen emission.

Type K—A film having high speed for X-ray or gamma-ray exposures.

Type M—Similar to Type A except that it has finer grain and lower speed.

No-Screen—A film which is somewhat higher in contrast and lower in speed than Type K.

Further details may be obtained by addressing your request to the X-ray Division, Eastman Kodak Co., Rochester 4, N. Y.

⁵ The exposure chart must be based upon the minimum film density used, as in this case, or a suitable correction factor must be applied to exposure values read from the chart.

³ The photographic reciprocity law states that the same result is obtained with the same exposure, regardless of the values of intensity and time. This seems to be quite accurately true for direct X-ray and gamma-ray exposures, but not for light exposures, such as is the case when fluorescent intensifying screens are used. The reader is referred to some of the publications listed at the end of this article for more detailed information on failure of the reciprocity law.

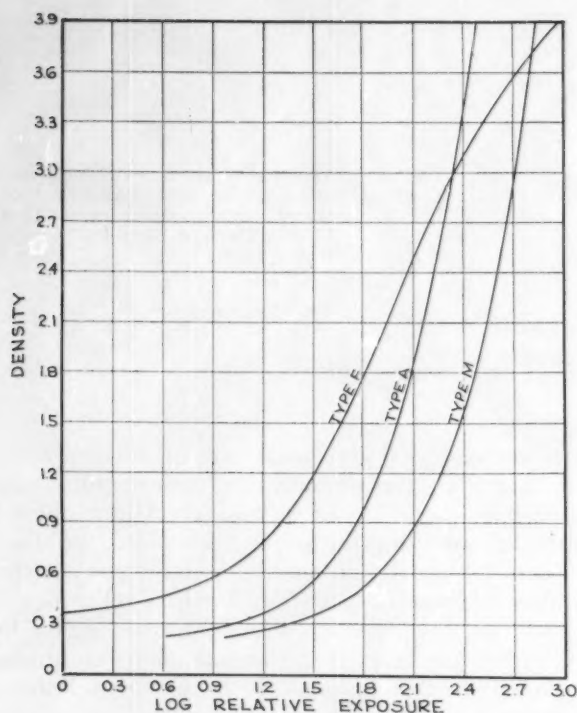


Fig. 4.—Direct X-ray Characteristic Curves of Three Industrial X-ray Films.

Development was in Kodalk X-ray Developer for 5 min. at 68 F.

NOTE.—All characteristic curves shown in this paper were obtained under the following common conditions: 100 kv.; with 0.2-in. aluminum filter; development for 5 min. with occasional agitation in Kodalk X-ray Developer at 68 F.

luminator available. Thus, an exposure of 14 milliampere-minutes is required to produce a density of 0.8 through 2.5 in. of aluminum at 100-kv. peak (see Fig. 2). Other densities in the radiograph will be higher since only 1.4 milliampere-minutes would be required to yield a density of 0.8 through 1 in. of aluminum. The subject contrast is therefore $14/1.4 = 10$. The logarithm of 10 is 1.0. The curve for Type A film in Fig. 4 shows that a density of 0.8 corresponds to a log relative exposure of 1.70. The log relative exposure for the 1.0-in. thickness is therefore $1.00 + 1.70 = 2.70$ and gives a density above 4.0, which is much too high, since it has been assumed that the illuminator is not bright enough for densities above 3.0. One of the most satisfactory solutions for a problem of this kind is to make separate exposures for the thicker and thinner portions of the specimen so as to stay within a reasonable density range for each thickness. Economy, however, may dictate a single exposure even though this is not quite the best procedure.

If either the subject contrast or the film contrast had been sufficiently low in the example just given, a satisfactory solution could have been obtained for a single exposure. Figure 2 shows a graph for 130-kv. peak with 0.079-in. copper filter at the tube. Since the slope is less than that for the 100-kv. peak line, it represents lower subject contrast. By utilizing this curve in the same manner as was done with the 100-kv. peak curve, it is found that the subject contrast for 1.0 to 2.5 in. of aluminum is $17/4.2$ or 4.0. The logarithm of 4.0 is 0.60. This is to be added to the log relative exposure of 1.70, which is the value for a density of 0.8 for Type A film (see

Fig. 4). The sum is 2.30, which is the log relative exposure value for a density of 2.8. Thus, an exposure of 17 milliampere-minutes at 130-kv. peak with 0.079-in. copper filter yields a density range between 0.80 and 2.8, which is below the upper limit assumed for satisfactory viewing.

It may be of interest to calculate the exposure which will produce a good radiograph if a film of low contrast is used instead of reducing subject contrast with harder radiation. According to Fig. 2, a density of 0.8 will be obtained on Type F film with an exposure of 4.2 milliampere-minutes through 2.5 in. of aluminum at 100-kv. peak. (Milliampere-minutes from the chart (14.0) multiplied by the film exposure factor (0.3) give an exposure of 4.2 milliampere-minutes.) The 1.0-in. part would require only 0.42 milliampere-minute to produce the same density. Thus, the subject contrast is $4.2/0.42 = 10.0$, the same as in the first calculation given, since metal thickness and radiation are the same. The curve for Type F film, Fig. 4, shows that the log relative exposure for a density of 0.8 is 1.2. The logarithm of 10.0 is 1.0. Thus, $1.0 + 1.2 = 2.2$, the log relative exposure corresponding to a density of 2.7 on Type F film. An exposure of 4.2 milliampere-minutes at 100-kv. peak will therefore produce a radiograph whose density limits are within those prescribed.

The procedure in these examples illustrates the principles of the method but would be awkward to use in practice since the operator might make several trial calculations before arriving at a satisfactory answer. What is needed is a method in which the acceptable density limits can be applied directly to the exposure chart, and the kilovoltage and exposure for a given specimen then read off.

Parallel lines are drawn on a transparent cellulose acetate sheet such as a fixed-out X-ray film in the manner shown in Fig. 5. The spacing between the base line and the line immediately above is the log relative exposure interval for Type A film between $D = 0.8$ and $D = 3.0$. It is laid off to the same scale as the ordinate scale of the exposure chart. Similarly, the distance from the base line to any other line parallel to it can be made to correspond to the log relative exposure interval for other density limits and films. This transparent guide is moved up and down on the exposure chart with its lines parallel to the thickness axis. The two guide lines being used

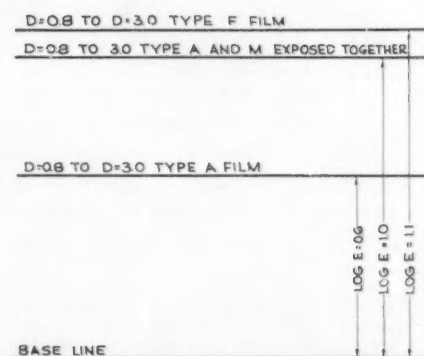


Fig. 5.—System of Lines Drawn on Transparent Sheeting to Be Used in Connection with an Exposure Chart for Quickly Estimating Radiographic Exposures of Multi-Thickness Specimens.

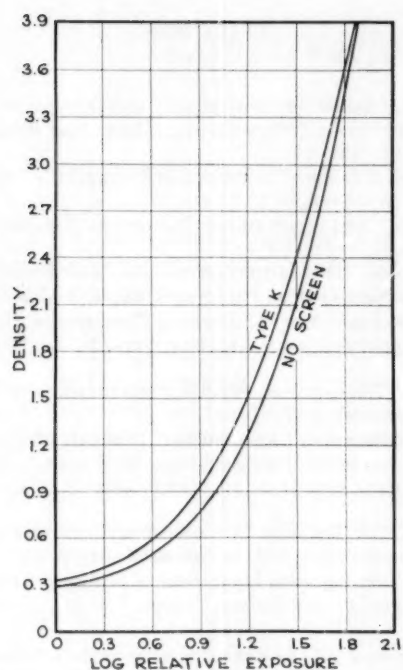


Fig. 6.—Direct X-ray Characteristics of No-Screen and of Type K Films.

Curves for Type K and No-Screen films are in the proper relative position and plotted to the same abscissa scale as Fig. 4.

form a rectangle with the two vertical lines of the exposure chart which mark the thickness limits of the specimen. The correct kilovoltage is the one whose graph intersects diagonally opposite corners of the rectangle and the correct exposure is indicated at the intersection of the upper guide line with the exposure scale. Since there is but one graph on a gamma-ray exposure chart, this procedure will show limiting thicknesses for the prescribed densities.

If the chart shows that the thickness range is too great for a single exposure under any conditions, it may be used to select two different exposures to cover the range. Another way is to load the cassette with two films of different "speed" and expose them simultaneously. Here again, the chart may be used to select the technique. The log relative exposure range for two films of different speed, when used together in this manner, is the log exposure difference between the value at the low-density end of the faster film curve and the high-density end of the slower film curve. Referring to Fig. 4 and assuming the use of film Types A and M, the result is 1.0, which is the difference between 2.7 and 1.7. It is necessary, of course, that the films be close enough together in speed so that they will have some "overlap" on the log E axis.

Several factors in the procedure outlined have a direct influence on the accuracy with which exposures can be predicted. Exposure charts are prepared ordinarily by radiographing some kind of step tablet. Since the proportion of scattered radiation depends upon thickness of material and therefore upon the distribution of the material in a given specimen, there is no assurance that the scattered radiation under different parts will correspond to the amount under the same thicknesses of the step tablet. In fact, it seems unreasonable to expect exact

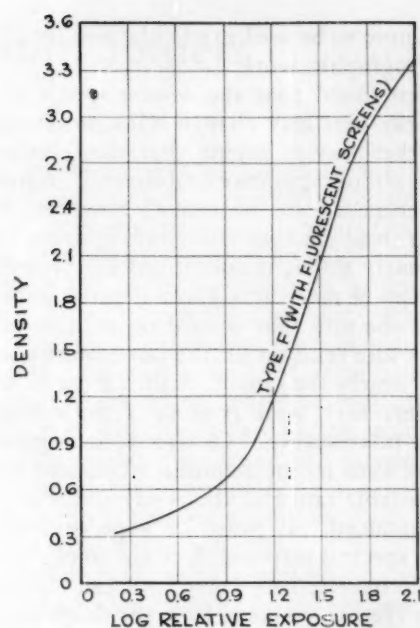


Fig. 7.—Fluorescent Intensifying-Screen Characteristic of Type F Film.

Its position relative to the abscissa scale is arbitrary and bears no specified relation to the location of curves in other figures.

correspondence between scattering conditions under two objects whose thicknesses are the same but in which the distribution of material is quite different. Naturally, the more closely the distribution of metal in the tablet resembles that in the specimen, the more accurately will the exposure chart serve its purpose. For example, a narrow tablet would approximate the scattering conditions for specimens containing narrow bars.

Films from which characteristic curve data are obtained should be processed under the same (or equivalent) conditions as the radiographic films. Time, temperature, and degree of exhaustion and agitation of developer are all variables which affect the shape of the characteristic curve and should therefore be standardized. When temperature or amount of exhaustion of developer do not correspond to the original conditions, proper compensation can be made by changing the time according to schedules available. This method for estimating exposures will yield the most reliable results when care is taken with details of processing.

The shape of the characteristic curve is only slightly affected by changes in X-radiation quality (wave length distribution). Considerable change in kilovoltage or filtration is necessary before any change of shape can be detected with certainty. This quality effect on the shape of the curve is so slight that it is of little practical importance over a range of conditions such as are given in Fig. 1. Since X-ray intensity varies rapidly with kilovoltage, characteristic curves made at different kilovoltages are displaced along the log exposure axis. This is of no significance in the present discussion because the log exposure axis shows relative values only. Exposures made at 140-kv. peak through $\frac{1}{2}$ in. of steel, for example, should therefore be adequate for making the characteristic curve which would be used in connection with this exposure chart. Thus, a "middle ground" of quality will

serve for a curve to be used in calculations for one general class of radiographic work.

It has been found that the *relative* speeds of different types of X-ray film may change with radiation quality. This is another way of saying that the relative spectral response of various types may be different. Carefully controlled experiments are necessary, however, to enable one to detect these changes under radiographic conditions unless extremely different conditions are provided. If a radiograph can be made at a given density with half the exposure on one film that is used on another at, say, 80 kv., the exposure relation for the same density at 100 kv. will be very nearly the same. A shift from 80 kv. to 200 kv., however, may well produce a noticeable change in the speed relationship. Of course, it is possible that two different films might maintain a constant speed ratio over the available range of the X-ray spectrum, but this cannot be assumed. It must be kept in mind that a difference in spectral response does not imply a change in shape of the characteristic curve, nor can conclusions be drawn about spectral response from the shape of the curve. The characteristic curve is strictly a density-exposure relation and does not indicate anything about wave length response.

Materials Situation in 1942 and 1943

THE FOLLOWING notes excerpted from an extensive summary of a report on war production progress made by Donald M. Nelson may be of some interest to members. The detailed report covers munitions, construction and plant facilities, etc. Only that part relating generally to materials is condensed here.

MATERIALS IN 1942

In 1942 military consumption and export of strategic materials rose sharply. For example, at the end of 1941 about one-quarter of total steel consumption was in direct military use; at the end of 1942 direct military use and export to our allies accounted for over two-thirds. Military consumption of aluminum in 1942 was 1,177,000,000 lb., or 168 per cent higher than in 1941. In 1941 about two-thirds of military consumption of aluminum was for aircraft; in 1942 the ratio was almost 80 per cent. Exports of aluminum rose by 336 per cent. The story for other materials is similar.

This increased flow of materials into direct military production and exports came chiefly from the expansion of domestic supply and the reduction of certain civilian uses. The domestic output of many key materials increased substantially in 1942. Production of chromite rose by almost 700 per cent; magnesium by 220 per cent; aluminum, 77 per cent; alloy steel, 38 per cent; molybdenum, tungsten and vanadium, 40 per cent.

In 1942 the beginnings of a joint control of the international flow of raw materials by the United States and British governments appeared, with the creation of the Combined Raw Materials Board. By joint agreement, the United States was allotted all rubber exports from South America and Liberia, plus a portion of Ceylonese exports. A similar arrangement has been made in the case of tin.

Toward the end of the year, the Controlled Materials Plan was adopted, providing over-all controls extending throughout the production process. Full determination of the flow of all resources in a complex war economy is undoubtedly unattainable, but important steps were made toward this objective.

MATERIALS IN 1943

Needs of military production during 1943 call for much greater quantities of almost all critical materials than in 1942. Requirements for steel

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are up 31 per cent. Aluminum mainly for airplane manufacture, and nitrogen for explosive production, are up over 100 per cent. Phenol and toluene, also essential for the production of explosives, are likewise up over 100 per cent. Magnesium is up over 200 per cent.

An even larger increase—450 per cent—is expected in the direct military use of ethyl alcohol, principally for the synthetic rubber program and for making smokeless powder. Copper, almost alone among the leading industrial materials, shows less than a 10 per cent increase from 1942 to 1943, reflecting the great difficulty of increasing supplies of that metal.

Exports were also scheduled to advance substantially for most materials, except copper. Outstanding is a sevenfold expansion in magnesium shipments. Exports of toluene explosives are expected to rise about 70 per cent.

These increased requirements for materials for military use and for export during 1943 must be met through corresponding increases in new supply during the year, that is, from added domestic production and higher imports.

Unlike the 1942 situation, only limited quantities of most scarce materials can be rendered available by further reduction in the civilian economy. Nor is it possible, for most materials, to deplete stocks further without endangering the production program itself.

By the end of 1942, restrictions on nonessential uses of most metals had become so rigid that virtually no further diversion to military production can be expected from this source. The restrictions in effect at the beginning of 1943 were severe. Allotments for such uses as railroad equipment and maintenance, agricultural tools and machinery, and industrial repairs and maintenance are being increased above estimates made last December.

Outside the field of metals, the situation appears to be more flexible. Sharp reductions can still be made in the nonmilitary use of lumber, imported cordage fibers, and other commodities.

The balance between supply and requirements for most critical materials should apparently improve somewhat during 1943, but there are many uncertainties that may well affect hoped-for importation and production materials.

The scarcity of vital materials will remain a critical limiting factor on war production during 1943. The tightness of steel, copper and aluminum, especially, necessitates prompt and decisive shifts if we are to avoid cut-backs in projected programs.

Conservation of Tin in Soft Solders*

By D. L. Colwell¹ and W. C. Lang¹

NECESSITY FOR TIN CONSERVATION

WHEN JAPAN captured the East Indies and Malaya, our principal source of tin fell into enemy hands. Due to destruction of dredging and refining facilities, it will be several years from the time we recapture this area before any appreciable amount of tin is received from there. In the meantime, our virgin tin requirements must be met from the comparatively small stockpile built up before the war, which was augmented by limited imports of pig tin and tin concentrates from South America and Africa. Labor and transportation difficulties make these imports uncertain. With efficient conservation and continued favorable progress on the military front, this stockpile should carry us over even a long war, but with wasteful use of tin or serious military reverses we could be thrown into a desperate position quickly. It is essential, therefore, to exercise the utmost conservation. We must play safe.

In recent years the largest single item of tin consumption in the United States has been the manufacture of tin plate. The consumption of tin in solder represented the second largest use. In 1940, a pre-war year, this use of tin amounted to 19,019 long tons, and in 1941 it was increased to 28,225 long tons.² Conservation measures since put into effect have decreased the solder demand for tin until it is now a very poor third, and the tin content is secured largely from secondary metals.

The Conservation Division of the War Production Board lists the critical non-ferrous metals in this order: aluminum, cadmium, bismuth, tin, magnesium, copper, zinc, all of which are starred in Group I, of the April "Material Substitutions and Supply List"³ indicating that they are the most critical of the metals and are insufficient for war and essential civilian demands. The lower the tin content of solders, the greater the proportion of this tin that can come from secondary sources, as these sources are largely lead-base alloys. The common non-ferrous metals in Group II, which at the present time are sufficient to meet war demands plus essential civilian demands, include only mercury and silver. In Group III, lead, antimonial lead, and antimony are listed as common non-ferrous metals available in quantities sufficiently great to consider them as possible substitutes. The metals to replace tin should come from Group III preferably, or Group II; namely, lead and antimony, or silver.

The most certain way to eliminate the use of tin in solder is to eliminate the soldering operation entirely, and in many cases assemblies can be designed to take advantage of other methods of joining. Spot welding and

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication, or for the attention of the authors. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia 2, Pa.

* Presented at the Forty-sixth Annual Meeting, Am. Soc. Testing Mats., Pittsburgh, Pa., June 28–July 2, 1943.

¹ Deputy Chief, and Consultant, respectively, Materials Branch, Conservation Division, War Production Board, Washington, D. C.

² Minerals Yearbook, p. 713 (1941).

³ This list, issued periodically, groups more than 500 materials according to necessity and availability. Copies of the latest list can be obtained from the Conservation Division, WPB, Washington, D. C.

seam welding have replaced solder on many truck fuel tanks, and could be much more widely used on sheet metal structures. By ingenious design, cemented crimped joints sometimes give better results than solders. Silver brazing by electrical resistance methods is replacing soft solder for joining commutator bars, field windings in large motors and generators, and in many other applications in the electrical field. Copper-hydrogen brazing may often be considered where equipment is available and production sufficiently great. In many instances these assembly methods appear to be costly but the fact is often overlooked that soft soldering is also costly inasmuch as high tin solders are among the most expensive of our common engineering materials.

An attempt is made in this presentation to coordinate some of the available evidence on solders, with particular reference to those utilizing lead, antimony, and silver as the more readily available non-ferrous metals. Little of the information presented was original with the authors, but in coordinating the experiences of others it is hoped that further measures of tin conservation may be expedited.

LEAD-TIN SOLDERS

A solder is judged largely by certain fundamental properties, particularly the solidus and liquidus temperatures, giving the melting range, and the ability of the solder to alloy with the base metal. In the lead-tin system, the eutectic occurs at 62 per cent tin and 361 F. The solidus is horizontal at this temperature from 19.5 per cent tin to 97.4 per cent tin.⁴ The natural step, therefore, in attempting to reduce the tin content of a 60–40, 50–50, or 40–60 tin-lead alloy is to lower the proportion of tin to lead. This can be done down to 19.5 per cent tin without changing the solidus, but the liquidus rises steadily so that the effect is a wider freezing range and higher flow temperature. As the tin content is decreased to 19.5 per cent, the resulting wider freezing range may be undesirable for some applications, for during the freezing period the solder has practically no strength. The so-called "hot shortness" difficulties can often be eliminated by maintaining rigid alignment of joint members until the solder has completely solidified. With reduced tin content, the resulting higher liquidus temperature necessitates higher heat input in the soldering operation. Below 19.5 per cent tin, the solidus rises abruptly, resulting in narrower freezing ranges. These properties of various tin-lead compositions are indicated in Table I.

TABLE I.—PROPERTIES OF TIN-LEAD SOLDERS.^a

Composition, per cent		Temperature, deg. Fahr.		
Tin	Lead	Solidus	Liquidus	Freezing Range
15	85	437	543	106
20	80	361	523	162
30	70	361	486	125
40	60	361	453	92
50	50	361	421	60
60	40	361	372	11

^a Data selected from A.S.T.M. Tentative Specifications for Soft Solder Metal (B 32–40 T), 1942 Book of A.S.T.M. Standards, Part I, p. 1411.

⁴ W. A. Cowan and G. O. Hiers, "Constitution of Lead-Tin Alloys," *Metals Handbook*, p. 1525 (1939).

LEAD-TIN-ANTIMONY SOLDERS

Considerable work has been done during the last century on antimony additions. The use of antimony has been given impetus by its comparative availability at the present time. It is frequently present in the types of secondary lead-base alloys most used in solders, and it is cheaper than any other metal commonly used in solders, except lead. Antimony is also desirable because it alloys with iron and copper as does tin. In most solders it exercises a great influence in lowering the liquidus temperature. For some alloys the addition of antimony also raises the solidus temperature and results in a narrower freezing range.

The work done by the British Non-Ferrous Metals Research Assn. is notable. Nightingale reports that antimony can be used to replace tin and that the tin content can be reduced by 2 per cent for every 1 per cent of antimony added until the antimony content reaches 6 per cent of the tin content.⁵ Except in the solders with very low tin, greater additions result in the formation of the familiar tin-antimony cubical crystals, causing the solder to become sluggish.

HIGH LEAD-SILVER SOLDERS

The use of silver as an alloying element in soft solders has been common both here and in England for a number of years. This also has been given impetus by the scarcity of tin. High lead-silver alloys have been used successfully in applications such as airplane radiators and electric motors where maintenance of strength at elevated temperatures is required.

Silver and lead form a eutectic at about 97.7 per cent lead, melting at 579 F.⁶ Inasmuch as most lead-silver solders are of a composition close to the eutectic, the melting range is very narrow. Higher soldering temperatures are also required because of higher liquidus temperatures, and additions of tin and antimony are sometimes made to lower the liquidus temperature as well as to broaden the melting range.

⁵ S. J. Nightingale, "Tin Solders," Second Edition, pp. 30-31, Chemical Publishing Co., Brooklyn, N. Y. (1942).

⁶ A. J. Dornblatt, "Constitution of Lead-Silver Alloys," *Metals Handbook*, p. 1523 (1939).



Fig. 1.—High Lead-Silver Solders Have Contributed to the Tin Conservation of the Can Industry.

One of the early tin-free solders was developed several years ago by the Westinghouse Electric and Manufacturing Co. This alloy is a variation of the eutectic lead-silver solder and contains 2.5 per cent silver and 0.25 copper, remainder lead.⁷ It has been one of the more widely used of the silver-bearing soft solders for high-temperature electrical work.

LEAD-TIN-SILVER SOLDERS

While the lead-silver system offers the ultimate in tin conservation, the lead-tin-silver system offers some logical solder compositions. The straight lead-silver alloys can be used successfully on brass, copper, tin plate, hot-dip lead coatings, copper plate, or silver plate, with slight modification of the usual soldering techniques. Dip and torch methods of soldering do not give good results on uncoated steel, although satisfactory joints can be produced by the hand iron method on uncoated steel or electro-lead-coated steel. For dip soldering where high temperatures can be used, alloys containing 0.5 to 1.25 per cent silver, 5 to 10 per cent tin, remainder lead, appear to be promising. Where lower working temperatures are required, the tin content can be increased to 15 or 20 per cent. These alloys usually give better results for soldering zinc-coated metals than solders containing more than a few tenths of a per cent of antimony.

Some can makers in using a high lead-silver solder have preferred to start with a solder containing 2.5 per cent silver, and 97.5 per cent lead. The bath rapidly picks up tin from the tin plate to a concentration of about 5 per cent, and it is reported that joints made with this solder are about 10 per cent stronger than those made with the conventional tin-lead solders. Some changes in equipment were necessary because of the higher working temperatures, and the narrow freezing range necessitated development of slightly different wiping techniques. Ordinary tin cans now in production using high lead-silver solder are illustrated in Fig. 1. The reduction in tin consumption from 4.07 lb. to 0.80 lb. of tin per thousand cans is largely due to the use of the electrolytic plate bodies and bonderized ends, but the use of tin-free solder accounts for 0.40 lb. of this reduction. In the tip soldering of condensed milk cans the quick-setting property of lead-tin-silver solder plugs the aperture more quickly and prevents drops of solder falling into the can.

Familiarity with the lead-silver alloys has influenced development work done by many different investigators. An initial trend was noted toward the use of silver in tin lead solders with reduced tin content. It was reported that in many cases silver imparts beneficial characteristics, such as increased strength, and improved creep resistance.⁸ Wide variations in silver and tin contents

⁷ R. H. Leach, J. R. Freeman, Jr., and Samuel Epstein, "Brazing and Related Joining Methods," *Metals Handbook*, p. 1212 (1939).

⁸ British Non-Ferrous Metals Research Assn., Report 1A, Private Communication, November, 1942, Capper Pass and Son, Ltd., Bristol, England.

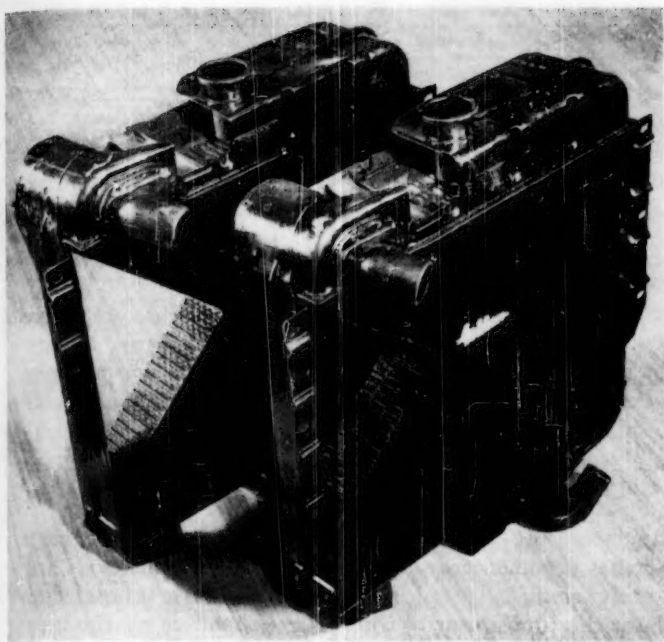


Fig. 2.—Composite Brass and Steel Radiators, Both Tubular and Cellular Types, Are Built with Low-Tin Solders. (Radiators by courtesy of Fedders Manufacturing Co., Buffalo, N. Y.)

have been explored. Two of the compositions which have been used are 20 per cent tin, 1 per cent silver, and 15 per cent tin, 1 per cent silver, remainder lead.

Similar solders containing 5 and 10 per cent tin with 1 per cent silver have been used in an experimental way for face dipping composite steel and brass radiator cores of the cellular type. Results seem very promising and indicate that these solders exhibit good capillarity and wetting characteristics. Joints made with them have excellent strength and resistance to tear. Two radiators representing composite brass and steel construction are illustrated in Fig. 2. The tubular type on the right and the cellular type on the left both have been successfully built with a low-tin solder of this type.

It appears that if the silver content is too high in a lead-tin-silver solder, silver-tin needles are formed which produce detrimental properties. British investigators report that as tin is added to a lead-silver alloy with silver in excess of 1.75 per cent, the liquidus temperature rises abruptly and then falls slowly with increasing tin content.⁹ Their explanation is that as tin is added Ag_3Sn forms in the melt, necessitating a higher temperature to maintain the metal in a molten condition. Ag_3Sn crystals form on cooling and tend to produce brittleness.

The use of small additions of antimony in tin-silver-lead solders is a recent development. American practice to date indicates that such compositions will produce good results for many types of applications. Two popular compositions are 20 per cent tin, 0.5 per cent silver, 2 per cent antimony, remainder lead, and 20 per cent tin, 1.25 per cent silver, 1.5 per cent antimony, remainder lead. Similar compositions have been used with 15 per cent tin. One other composition reported to give good results for coating and soldering small sheet metal structures in the

same operation contains 2.25 per cent tin, 0.25 per cent silver, 2 per cent antimony, remainder lead.¹⁰

THE ADDITION OF BISMUTH OR CADMIUM

In attempts to lower liquidus temperatures of low tin solders, bismuth or cadmium has been added.¹¹ Bismuth in many compositions lowers the liquidus temperature about 8 F. for each 1 per cent of bismuth added. It has been stated that small additions of bismuth appear to improve wetting characteristics. This seems somewhat doubtful as no alloys of bismuth with iron¹² or copper¹³ at soldering temperatures are known. The usual complaint with bismuth-bearing solders is that "hot shortness" of joints results from its use due to the wider freezing range. In cases where low-working temperatures must be maintained, bismuth-bearing solders have been extensively used. The effects of cadmium are similar to those of bismuth except that the amounts required to lower liquidus temperatures are generally greater.

Both bismuth and cadmium are produced in quantities measured in pounds rather than in tons. Other more essential uses, such as the use of bismuth in pharmaceuticals and cadmium in electroplating, further diminish the quantities available for alloying, and both metals are extremely critical at the present time. Solders depending upon either bismuth or cadmium, therefore, offer little promise for replacing much tin-bearing solder except in special uses.

ZINC OR ARSENIC

The zinc-lead eutectic at 0.5 per cent zinc, melting at 604 F.¹⁴ indicates the necessity for a lower melting point constituent, and cadmium seems to be required also to obtain best results.¹⁵ Zinc has long been considered a harmful impurity and zinc-bearing solders are not widely used.

Dowdell suggests the use of arsenic in lead-antimony alloys for soft solders.¹⁶ The composition 0.5 per cent arsenic, 12 per cent antimony, remainder lead, is suggested with a liquidus temperature of 478 F. He recommends it for tin plate and bare steel but not for copper and brass. Soldering temperatures higher than those required for 50-50 tin-lead solder are necessary, and pre-tinning of the soldering iron by the use of a 30-70 tin-lead bath is recommended. No production experience is indicated.

TEST DATA

Capper Pass and Son, Ltd., have developed several solder compositions on the theory that the basis of a good solder is a suitable lead-base eutectic blended with another lead-base eutectic or with pure lead.¹⁷ Some of their data has been tabulated in Table II along with data on com-

¹⁰ Private Communication.

¹¹ Albert J. Phillips, "Bismuth Solders," *Metal Industry* (London), March 5, 1943, p. 150.

¹² R. M. Parke, "Constitution of Binary Alloys of Iron and Certain Other Elements," *Metals Handbook*, p. 352 (1939).

¹³ H. C. Jennison and Cyril Stanley Smith, "Properties of Commercially Pure Copper," *Metals Handbook*, p. 1389 (1939).

¹⁴ E. A. Anderson and J. L. Rodda, "Constitution of Zinc-Lead Alloys," *Metals Handbook*, p. 1748 (1939).

¹⁵ "Use High Lead Solders," *Steel*, May 18, 1942, p. 74.

¹⁶ R. L. Dowdell, M. E. Fine, J. F. Elliott, and I. C. Mattson, "A New Soft Solder," *Metal Progress*, January, 1943, p. 56.

¹⁷ British Non-Ferrous Metals Research Assn., Report 1A, Private Communication, November, 1942.

⁹ P. G. T. Gueterbock and L. G. Earle, "Notes on the Lead-Silver Base Soft Solders," Capper Pass and Son, Ltd., Bristol, England.

TABLE II.—PROPERTIES OF SEVERAL ALTERNATE SOLDERS.^a

Composition, per cent					Temperature, deg. Fahr.		
Silver	Tin	Anti- mony	Copper	Lead	Solidus	Liquidus	Freezing Range
1	....	....	....	99	579	604	25
2.5	....	....	0.25	97.25	576	590	14
2.5	....	....	....	97.5	579	579	0
0.25	2.25	2.0	....	95.25	457	577	120
1	5	....	....	94	561	572	11
....	19	1	....	80	365	523	158
0.42	20	....	....	79.58	352	523	171
0.75	20	....	....	79.25	351	523	172
1.5	20	....	....	78.5	350	517	167
0.43	20	1.01	....	78.56	356	511	155
0.5	20	2.0	....	77.50	363	505	142
1.25	20	1.5	....	77.25	354	504	150

^a Data selected from the following sources:
A.S.T.M. Tentative Specifications for Soft Solder Metal (B 32-40 T), 1942 Book of A.S.T.M. Standards Part I, p. 1411.
Emergency Alternate Provisions in A.S.T.M. Tentative Specifications for Soft Solder Metal, pink sticker for insertion in 1942 Book of A.S.T.M. Standards, Part I, p. 1411.
Private Communications from: British Non-Ferrous Metals Research Association, November, 1942; Copper Pass and Son, Ltd.; Chrysler Corp. Engineering Laboratories; American Smelting and Refining Company; Central Research Laboratory, National Lead Company Research Laboratories.

positions from other sources, indicating characteristics of some of the more desirable compositions of alternate solders.

Data on properties such as capillary rise, wetting ability, and strength of lap joints are purposely omitted from Tables I and II. Examination of data from several laboratories indicates that values are vitally affected by varying conditions of tests, and no apparent pattern could be discerned. One set of data would show higher values for one composition, while other data indicated lower values for the same composition. Generally, it was apparent that the strength of joints and the degree of capillarity secured with low-tin solders were of the same order of magnitude as those secured with high-tin solders. Improved wetting properties were indicated as the tin content was increased; but most of the improvement noted came from the first few percentages of tin which were added. Kies and Roeser present some data on strength tests and spreading tests on specific solders and also point out the need for a standard testing procedure for determining these properties.¹⁸

RELATIVE COSTS

Discussion of alternate solders is not complete without some mention of cost. With silver prominent in the discussion, there is an inclination toward the assumption that the use of low-tin solders involves additional expense. The contrary is usually the case because the silver additions are usually small and the tin reductions large, so that the net result is usually a lower material cost with the alternate solders than was the case with the previously used high-tin compositions. Table III presents a comparison, of material costs only, of the compositions listed in Tables I and II. These material costs are based on the virgin metal markets of May 7, 1943, and include no alloying, freight, or items other than metal entering into the cost.

COMMENTS ON SOLDERING METHODS

Methods for the application of conventional solders have been built up over a period of hundreds of years.

¹⁸ J. A. Kies, W. F. Roeser, and S. K. Gutterman, "Short-Time Tests of Low-Tin Solders Listed in Recent Federal Specifications," *Preprint No. 36*, presented at the Forty-sixth Annual Meeting of the American Society for Testing Materials, June 28 to July 2, Pittsburgh, Pa.

TABLE III.—COMPARISON OF METAL COSTS FOR SOLDERS.^a

Composition, per cent					Cost of Metal Per 100 lb.
Silver	Tin	Antimony	Copper	Lead	
....	60	....	....	40	\$33.80
....	50	....	....	50	29.25
1.5	20	....	....	78.5	25.29
1.25	40	....	....	60	24.70
2.5	20	1.5	....	77.25	23.83
....	....	....	0.25	97.25	22.65
2.5	....	....	....	97.5	22.64
0.75	20	....	....	79.25	20.44
....	30	....	....	70	20.15
0.5	20	2.0	....	77.50	19.02
0.43	20	1.01	....	78.56	18.47
0.42	20	....	....	79.58	18.33
....	20	....	....	80	15.60
....	19	1	....	80	15.24
1	5	....	....	94	15.24
....	15	....	....	85	13.32
1	....	....	....	99	12.97
0.25	2.25	2.0	....	95.25	9.31

^a Based on metal cost only—prices of May 7, 1943.

In attempting to use alternates to tin-lead solder the fact has become apparent that many of these methods are largely empirical, and in many cases little knowledge about the limitations of soft solders is shown by the user either in the design or in the application stage.

When considering soldering techniques, it is noted that the high-tin solders have been popular principally because they had low working temperatures and little care was required to secure serviceable joints. It has been demonstrated by widespread use that the alternate alloys have satisfactory physical characteristics and produce sound joints, but it is usually necessary to exercise more care in processing to secure good results. It is impossible to solve specific soldering difficulties by generalizations, but some discussion of fundamentals should be of value. The following comments, therefore, on such fundamentals as design, cleaning, fixtures, and fluxes may be found helpful. To use low tin solders successfully, it is first necessary to realize their fundamental differences and then to choose methods to overcome them.

Design:

Faulty design is frequently responsible for service difficulties as well as for excessive use of solder by the workmen. Butt joints and simple lap joints should be avoided. Lockseam or rolled joints are stronger and in most cases lend themselves to more economical soldering techniques. This is particularly true of sheet metal structures which are often difficult to jig properly, and have a tendency to buckle when heat is applied. Tack brazing, spot welding, riveting and sheet metal screws can frequently be used to hold parts in proper alignment for subsequent soldering operations.

Excessive use of solder can be reduced by observing a few simple precautions. Joints extending around curved surfaces should be avoided wherever possible because of the difficulty of retaining the molten solder around the curve, even when the slower hand iron method is used. The location of soldered joints in depressions should be avoided as there is a tendency for workmen to fill such depressions with solder. Sufficient space for soldering operations is essential, particularly when inflammable materials such as rubber insulation are located near the soldered joints. Soldering operations should be mechanized to the greatest extent possible. If parts can be designed for soldering by

oven sweating, dipping, induction or resistance heating, or torch methods, much of the human element can be eliminated and more satisfactory results secured.

In some types of structures, such as the cellular type radiator, solder consumption can be reduced by taking advantage of the fact that the capillary rise of solder is greatly decreased by a slight widening of space between the metals being joined.

Instruction of Workmen:

One of the best plans to give a workman proper assistance on soldering operations is to have the engineer lay out the job in advance, taking into consideration the various aspects that are likely to cause trouble. The engineer should then issue the detailed instructions including emphasis on the changes in technique necessary for each particular operation. The fact that a workman has performed soldering operations for a number of years is often taken as evidence that he can be turned loose on any job without specific instructions. It often happens that new employees properly instructed turn out better work and are more economical in the use of solder than men who have soldered for years. This is particularly true when using the lower tin content solders which require somewhat different operating techniques.

Preparation of Work:

It is of vital importance that work for soldering be properly prepared. Absolute cleanliness of the work is essential. Many joint failures and much waste of solder can be traced to faulty cleaning before soldering. Slightly roughened or etched surfaces greatly facilitate the spread of the solder. When soldering wires, care should be taken to be sure that films of lacquer are not present under insulation. In all cases, rust, films of oxide or grease, dirt, and other foreign matter should be removed. This can be done by the use of alkaline metal cleaners, vapor degreasers, or acid pickling, depending on the nature of the work. For best results in soldering malleable or gray iron castings, mold sand and carbon must be completely removed from the surface to be soldered, and one very effective way to accomplish this is to use a molten salt cleaning process. Properly cleaned work can usually be soldered with less active fluxes, and consequently danger from corrosion by the flux is diminished.

For many applications it is advisable to use jigs and fixtures for properly holding the parts together for the soldering operation, and a great deal of thought should be given to the proper design of such jigs. If they are difficult to use or involve too much time, workmen will avoid them. In some cases it will be necessary to care for expansion of the heated metal in jig design. Sometimes this can be accomplished by the use of spring pressure rather than rigid fixtures. In all cases jigs and fixtures should be insulated where heat losses from contact with the work can occur.

Fluxes:

Proper fluxes may greatly facilitate soldering operations, but there is usually a tendency on the part of workmen to use too much flux and to use it carelessly. There are numerous fluxes on the market, some of which are reasonably noncorrosive, and others require precautions against subsequent corrosion.

Rosin-base fluxes usually decompose readily with heat to

form an inert, moisture-impervious residue. Certain organic compounds such as stearic acid, and amines or amides are sometimes used, and phosphoric acid can be used successfully when soldering copper or brass. The use of these fluxes, however, does not appear to be nearly as widespread as the use of zinc chloride or mixtures of zinc chloride and ammonium chloride with a small amount of free hydrochloric acid. Zinc chloride fluxes are corrosive and, furthermore, are hygroscopic, increasing corrosion difficulties. They may be used as emulsions with greases, in aqueous solutions, or in the molten condition. Work should be neutralized and thoroughly washed following the use of corrosive fluxes.

Certain comments on the technique of soldering may be found helpful in making the most efficient use of alternate solders. Electrical resistance and induction heating methods for many operations have come to the fore recently and may be adapted to many individual soldering operations. Very rapid heating can be secured by these methods. Wherever possible the use of inserts or gaskets of solder foil is helpful, as this insures the solder reaching the surfaces to be joined where it will do the most good. Solder "plastered on" the outside of a joint is practically useless.

Wiping Solders:

With wiping solders, usually used in joining lead pipe and lead cable sheathing, the solder is applied to the prepared joint in a molten condition and chills rapidly, becoming pasty. It is caught on a leather or cloth pad and the pasty solder is then manipulated with the wiping pad to form the joint. Excess solder is removed before it is completely solidified. British practice confines the tin content of wiping solders to a 30 per cent maximum. In this country it is frequently claimed that solders containing less than 38 per cent tin are unsuitable for wiped joints on pressure water lines. In view of the British practice and also in view of the desirability of a wide freezing range for best wiping conditions, the necessity for more than 30 per cent tin seems very questionable. A 30-70 tin-lead solder has the same solidus as a 40-60 tin-lead solder, and a considerably higher liquidus, giving a wider freezing range which should be more desirable for a wiping solder. The addition of 2 per cent antimony is said to improve the consistency of the pasty solder.

In many cases wiping solder may be entirely eliminated by the substitution of lead welding. Classes to teach plumbers the technique of welding lead by use of the oxy-acetylene torch have been formed in many trade schools. Wiped joints in lead pipe or fittings which are ordinarily made on the bench could very readily be welded, thus eliminating the wiping solder entirely. It is also possible by a study of joint design to reduce greatly the amount of wiping solder required. By a study of splices, the Western Union Telegraph Co. was able to reduce its solder consumption for this purpose by more than half. In addition to this, tin contents were lowered and trouble with leaky splices due to porosity was greatly reduced.¹⁹

Other Methods of Soldering:

When assemblies are of such a nature that they hold

¹⁹ Private Communication.

themselves in the proper position, bake or furnace soldering may be used. Solder is applied by precoating, or a coupon of solder foil is placed between the fluxed parts, and the whole assembly is brought to soldering temperature in an oven and subsequently cooled without disturbing the joint. A typical assembly normally soldered by this method is a tube and fin type radiator core where the tubes are precoated with molten solder in the tube machine operation. Stainless steel water canteens are also soldered by this method, although the soldering operation here is completed by going over the crimped joints with wire solder as the heated canteen leaves the oven. By using higher soldering temperatures, the low-tin solders and in some cases the high lead-silver solders have been successful in this type of soldering.

The dip method of soldering is frequently used in soldering small parts where the operation is repeated as, for example, connector tips for electrical harnesses. These are often soldered to fifty or more wires by a single dip in the molten solder. Cellular type radiators are also soldered by the dip method. After careful assembly and jiggling, the faces are fluxed and then dipped in a solder bath to a depth of about $\frac{1}{4}$ in. The solder penetrates upward through the joints by capillary attraction. By the use of higher operating temperatures and proper flux concentration, very low tin content baths have been successful. The lower tin content has the additional advantage of dissolving less copper from the radiators, and in this respect control of the bath is simpler with the lower tin solder. Mechanical lines for soldering side seams of tin cans make use of a variation of this method in which a roll carries the molten solder from a bath into the lockseam joint.

Hand Iron Soldering:

Many of the usual hand iron soldering applications can be more readily performed with the gas torch. This method gives rapid heat input and simplifies the obtaining of higher working temperatures usually involved in the

use of low-tin solders. For use with high lead-silver solders, a reducing flame is recommended, as it has been found that the use of this type of flame improves the wetting qualities of the solder.²⁰ It is usually advisable to use wire solder or inserts of solder foil in the joints for torch soldering.

Hand iron soldering seems to involve greater difficulties with alternate solders than other methods of soldering. The heat input of soldering irons is usually adjusted to lower temperatures than are required for alternate solders. Complaints of brittle or cracked solder or failure to "stick" are usually due to an iron that is not sufficiently hot. Higher heat input may be secured by an electric iron of larger capacity, by gas fired irons, or by the use of larger size manually heated irons. It is usually necessary to increase the heat input in hand iron soldering when a change is made from a high-tin to a low-tin solder. It is very desirable to maintain soldering irons in a clean, well dressed, tinned condition to secure the best possible heat transfer. It has been suggested a hand iron may be heated in a bath of molten solder covered by a layer of molten flux in order to eliminate oxidation and keep the iron clean and well tinned.¹⁶

CONCLUSION

The authors have endeavored to point out that in the absence of a plentiful supply of tin much of the work formerly done by high-tin solders can be just as satisfactorily performed by solders of alternate compositions containing either no tin at all or much less tin than was previously used. Typical compositions are given and suggestions are made for the proper handling of these various alternate compositions. It is felt that much of the residual demand for high-tin solders can be eliminated if proper methods of using alternate compositions are installed.

²⁰ "Utilization of High Lead Solders," National Academy of Science Report, February 17, 1942.

DISCUSSION

MR. J. R. TOWNSEND.¹—The authors are to be congratulated for bringing together important data on this rather timely subject.

We have been able to demonstrate in the laboratory that an 85 per cent lead 15 per cent tin solder will do most of the soldering operations, and if properly used will produce an entirely satisfactory joint from the standpoint of vibration and strength. It can also be shown that silver-lead solders will also make satisfactory joints that will stand up. However, this is only part of the story. The rest of the story has to do with practical manufacturing considerations. Soldering in electrical and electronic apparatus often offers considerable difficulty. The limitations of design, particularly on air borne apparatus, require a large number of soldered joints to be placed in close proximity. Under such conditions it is virtually impossible to use low-tin solders or silver-lead solders, for the simple reason that these solders must be raised to a higher temperature than that of the higher tin solders. This requires either the use of hotter irons,

¹ Materials Standards Engineer, Bell Telephone Laboratories, Inc., New York, N. Y.

with the probable danger of burning nearby insulation, or that normal low temperature or average temperature irons be held in position a longer time.

This might be difficult for one who looks at this problem in the laboratory, but the actual fact of the matter is that in commercial soldering operations, in the plant, it is possible for one workman, after he learns to make soldered connections quickly, to make 10,000 or more connections in a single working day. Soldering at this rate, with a hand-soldering operation, requires the highest precision on the part of the operator and easily flowing solder. The resulting joints are good because of the short time of application of heating the area ambient to the joint. So that for many of the critical applications in the war, where soldering joints have to be made on important apparatus, it is necessary that higher tin solders be used, in spite of the fact that we are all anxious to save tin.

The authors have mentioned the matter of cost. The cost of the soldering joint is not exclusively the cost of the solder that is used in the joint but the over-all cost of the entire operation. To that I would add the value of the fidelity of the joint and its influence on the neces-

sity of having to repair the joint in service, in other words, the efficiency of the joint with respect to its life; consequently, the price or cost of the soldered joint is an overall thing and cannot be related solely to the cost of the solder itself.

One other thing that must be touched upon: In all of the important equipment that is being soldered today the fidelity of the joint is so important and so much depends on the joint being good at all times, that the only answer is in the use of high-tin solder, or, where possible, to resort not only to a soldering operation to make sure that there is low contact resistance between the joint parts, but also to have a supplementary mechanical bond, preferably on the side, if possible, away from the soldered joint, to insure that fatigue of the joint does not take place.

I have added these few comments to this rather excellent presentation of the subject of soldering merely to bring out the fact that there are many practical considerations to be decided in the plant on soldering methods.

MR. C. A. HILL.²—This discussion has covered nearly all uses of solder except one which has become prominent in the past 15 yr.; that is, the joining of copper tube and fittings. This tube ranges in size from very small, through the sizes used in house piping, to the larger sizes up to 12 in. in diameter used mainly in paper mills.

A satisfactory solder for this use must have adequate shear strength, ample resistance to "creep" at the temperature in service, and, what is important it must "flow" or spread readily to insure the complete filling of the joint. Solders with 40 per cent or more tin satisfy these conditions. Since these are not now available it is fortunate that the development of the lead-silver solders has given a workable substitute. The shear value and "creep" resistance of these lead-silver alloys is satisfactory.

Many users do comment on the higher fusion temperature and the less free flowing qualities both of the lead-silver solders and low-tin lead-base solders now being made. However, there is a notable absence of complaint as all recognize that these new solders will serve their

² Mueller Brass Co., Port Huron, Mich.

present purposes and have released tin for more important needs.

MR. G. O. HIERS.³ I might say at this time that the Government has cooperated nicely with industry in restricting the use of tin. The tin content of general purpose solder has been stepped down twice—once to 30 per cent and then to 21 per cent.

The industry at large has responded very well and, in some special cases, the Government has relaxed the general restriction by permitting a somewhat higher tin content.

MR. H. L. SMITH.⁴ It is important to have a thorough understanding of the use of low-tin solders. Due to their liquidus and solidus temperatures these solders are susceptible to hot short cracking. To eliminate hot short cracking it is necessary to remove strain from the joint during the soldering operations. If this is remembered, much greater success will be derived from the use of the low-tin solders mentioned.

MESSRS. D. L. COLWELL⁵ AND W. C. LANG⁵ (*author's closure, by letter*).—Present conditions indicate that it is necessary to conserve tin wherever possible to insure availability of this metal for essential military and civilian uses. Progress in realizing this conservation has been very gratifying. For many types of work further conservation is possible and desirable. It should be realized, however, that as indicated in this discussion, numerous problems still exist. It is likely to require much effort and ingenuity to solve some of these.

Indications are that, if necessary, we can get by with considerably less tin than was formerly anticipated. Should further conservation become necessary, it is likely that we will have to accept solders for some uses that are not so desirable as those normally used. Savings accomplished on work where alternate solders can be successfully used will make tin available for applications where it is still necessary to use high-tin solders.

³ Research Laboratories, National Lead Co., Brooklyn, N. Y.

⁴ American Smelting and Refining Co., Pittsburgh, Pa.

⁵ Deputy Chief, and Consultant, respectively, Materials Branch, Conservation Division, WPB, Washington, D. C.

XXXII. Long-Time Society Committee Members

Thirty-two in the Series of Notes on Long-Time Members

As a continuation of the series of articles in the ASTM BULLETIN comprising notes on the outstanding activities of long-time A.S.T.M. members, there are presented below outlines of the work of three additional members. In general, the men whose activities are described in this series have been affiliated with the Society for 25 years or more and have taken part in committee work for long periods of time. No definite sequence is being followed in these articles.

H. L. WHITTEMORE, Chief, Engineering Mechanics Section, National Bureau of Standards, Washington, D. C., graduated from the University of Wisconsin in 1903 with the degree of B.S. in Mechanical Engineering, receiving his M.E. degree in 1910. Following a short period of service with a machinery company in New Hampshire, he



H. L. Whittemore

H. M. Milburn

A. E. Flowers

later was Engineer with A. P. Hanson Co., Berlin, Germany, and Production Engineer for British Westinghouse Electric and Manufacturing Co., in Manchester, England. From 1906 to 1910 he was Instructor at the University of Illinois and later Engineer of Tests at Watertown Arsenal, which service was followed by faculty duties, including Professor of Mechanics at the University of Oklahoma, 1912 to 1917. He has been in his present position at the Bureau since 1917.

His membership in A.S.T.M. dates from 1911 and he has served on a number of A.S.T.M. committees including A-1 on Steel, E-1 on Methods of Testing, and a number of its sections including one on calibration of testing machines and apparatus, and the committee on impact testing.

Mr. Whittemore was co-inventor with S. M. Petrenko of a device widely used in calibrating testing machines, namely, the Whittemore-Petrenko Proving Ring which is a circular ring loaded along a diameter through flats ground on the outer cylindrical surface with a vibrating reed deflection measuring device. Later rings have included a system of applying loads through external bosses with the measuring device integral with an internal boss. These rings are portable up to large capacities. For his work in connection with proven rings, Mr. Whittemore in 1937 was awarded the Longstreth Medal by the Franklin Institute.

Mr. Whittemore is a member of a number of societies including The American Society of Mechanical Engineers, American Welding Society, and Washington Academy of Sciences. He is the author of many bulletins and publications issued by the Government and other organizations and societies.

H. M. MILBURN, Senior Engineer of Tests, Public Roads Administration, Federal Works Agency, Washington, D. C., a native of Detroit, Mich., is a graduate of the University of Michigan, 1903, with the degree of B.S. in Chemical Engineering. His first employment was with the Engineering Department of the District of Columbia in the inspecting and testing of paving materials. Later he was with the Conkling Chemical Co., and from 1908 to 1918 was in charge of the Testing Paving Laboratory of the City of Omaha, Nebr. He has been a member of the staff of the Bureau of Public Roads since 1918, having been Senior Engineer of Tests since 1928.

A member of A.S.T.M. since 1917, he has been particularly active in the work of Committee D-4 on Road and Paving Materials, at the present time is chairman of three of its subcommittees on ductility, solubility tests, and expansion joint materials, and serves on several other subgroups. He is the representative of Committee D-4 on Technical Committee X (conditioning and weathering) of Committee E-1 on Methods of Testing.

A member of the American Association of State Highway Officials, he has served for many years as chairman of its Committee on Materials' Division of Bituminous Materials. He is vice-chairman of the Technical Committee on Road and Paving Materials of the Federal Specifications Executive Committee, and is also active in the work of the Highway Research Board.

A. E. FLOWERS, Engineer in Charge of Development, DeLaval Separator Co., Poughkeepsie, N. Y., received

his education in the Memphis, Tenn., High Schools; later entered Sibley College, Cornell University, in 1898, winning a competitive undergraduate scholarship. He graduated in 1902, with the degree Mechanical Engineer in Electrical Engineering, after completing the regular curriculum and taking extra courses.

After employment at Westinghouse Electric and Manufacturing Co., he became instructor, assistant professor and associate professor of electrical engineering, Ohio State University, leaving to volunteer in 1917 in the Signal Corps, Radio Development Section, serving as Captain. He was then Test Engineer, National Aniline and Chemical Co., and Manager of Chemical Machinery Co. In addition to regular employment he has been engaged on special work with various power companies and electrical manufacturing companies.

Dr. Flowers took his graduate work at Cornell University and Union College. It is of distinct interest to note that both his Master's and Doctor's theses were printed in the A.S.T.M. PROCEEDINGS under the titles "Cylinder Friction and Lubrication Testing Apparatus" and "Viscosity Measurement and a New Viscosimeter."

In the Society he has been a member of Committee D-2 on Petroleum Products and Lubricants since its early days and of Committee D-9 on Electrical Insulating Materials since 1923, serving on a number of subcommittees, particularly sampling and gaging, turbine oils, and neutralization number in D-2, and on oxidation and electrical breakdown and moisture in oils in D-9.

He is a member of several societies, American Institute of Electrical Engineers, American Physical Society, American Society for Metals, American Association of University Professors, and The American Society of Mechanical Engineers.

He is the author of technical articles on friction, lubrication, viscosity, solid contact rectifiers, harmonic analysis of alternating currents, service characteristics of lubricating oils, solubility of water in oils, and the chapter on centrifuges in the *Chemical Engineers Handbook*. He has also taken out a number of patents in fields related to these subjects.

Dr. Flowers was the Guest of Honor at the Annual Dinner of Committee D-2, held during the Society Meeting in Pittsburgh, at which he was presented with a large "dispatch" type brief case. In his remarks Dr. Flowers paid tribute to the fine spirit of cooperative work which has always characterized the activities of the Society and pointed out the great need for something similar in the administration of our national and international affairs.

Applications of Structural Steels and Light-Weight Alloys

A RECENT PUBLICATION of the American Institute of Steel Construction may be of interest to a number of A.S.T.M. members. This is a 30-page report by F. H. Frankland entitled "Applications of Structural Steels and Light-Weight Alloys for Bridges, Buildings and Similar Structures." In discussing pertinent features and problems in connection with aluminum, magnesium, stainless steels, low-alloy structural steel, structural sheet steel, and standard carbon steel, frequent reference is made to the A.S.T.M. specifications covering these materials. Copies of this report can be obtained free on application to the American Institute of Steel Construction, 101 Park Ave., New York, N. Y.

Discussion of Paper on Stress-Strain Relations in Timber Beams (Douglas Fir)¹

Submitted by Charles S. Whitney:²

It is apparent that there is insufficient knowledge of the behavior of timber in flexure to form the basis of a satisfactory rational method of design of timber beams under the various conditions ordinarily occurring in practice. The subject is especially important now because of the trend toward the use of large laminated flexural members as arches and girders.

Dietz's research is of great interest and value but it is to be hoped that he will make a further study of his data and reconsider his conclusions. A study of available data on the peculiar mechanical characteristics of wood indicates that a satisfactory theory can be worked out which will explain all of the observed phenomena of timber in bending. The writer wishes to make the following suggestions:

1. That none of the theories so far advanced take into account the effect of shearing strains on the distribution of flexural stresses. (The observed warping of cross-sections could not occur without shear strain.) The importance of this may be realized when it is noted that the ratio of modulus of elasticity under direct tension to that in shear is about 18 for timber as compared to about $2\frac{1}{2}$ for ordinary materials which are approximately isotropic. The large shearing distortions cause important concentrations of stress which influence the flexural strength. It also appears that local strains due to concentrated loads perpendicular to the grain have important effects.

2. That the Bach-Baumann theory is satisfactory if modified to take into account the effect of shear and that it is then consistent with observed phenomena.

3. That the Newlin-Trayer fiber support theory is not confirmed by Dietz's tests and that it is without rational basis.

4. That there is no evidence that the observed reduction in modulus of rupture of rectangular beams as the depth increases³ is not due to the influence of shear strain and load concentrations.

The general manner of failure of timber beams has been understood for many years. In 1898, J. B. Johnson wrote,⁴ "Thus in the case of timber, for instance, the neutral plane at first lies in the center of gravity of the cross-section, but after the material has begun to crush on the compression side, the neutral plane rapidly moves toward the tension side of the beam and often, at final rupture, it lies very near this side, the tension stress area being a triangle of very long base (stress on extreme fiber) and very short altitude (distance to neutral plane). It is evident that, although the beam has long since failed in compression, if it be continuously deflected, failure must ultimately occur also in tension. When the material is weaker in tension than in compression, such double failure cannot occur, since the tension failure parts the body, and the rupture is complete. Evidently no general law can be given for distribution of the stress across the section after the elastic limit has been passed, other than to say it is that of the corresponding stress-diagrams of that material in direct tension and compression, respectively."

This is similar to the Bach-Baumann theory which Dietz finds consistent with his tests except that it cannot explain the different moduli of rupture obtained in deep and shallow beams. His tests show a shearing distortion of the cross-sections of the beams which he assumes to be related to the fiber support curve of Newlin-Trayer.

It has been assumed that the tests on beams of different depths which form the basis of the Forest Products Laboratory report are actually comparable but no supporting data are available. The writer has attempted to obtain the dimensions of the beams in order to determine whether the variation in moduli of rupture might be due to variation in shearing strains but is advised that the original data cannot be found. It is, therefore, possible that although the test specimens were designed so that there was no actual shear failure, the shear strains may have been greater in the deeper beams thereby reducing the modulus of rupture.

The action of shear strain in increasing the maximum fiber stress due to bending is shown by the accompanying Fig. 1.

Assuming a rectangular beam with a concentrated load at the center and simple supports, the distribution of horizontal shear at a section intermediate between the load and the support is shown approximately by Fig.

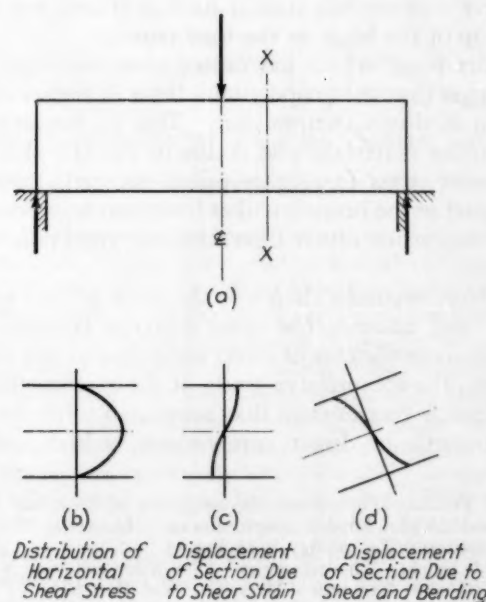


Fig. 1.

¹ Albert G. H. Dietz, "Stress-Strain Relations in Timber Beams (Douglas Fir)," ASTM BULLETIN, No. 118, October, 1942, p. 19.

² Consulting Engineer, Milwaukee, Wis.

³ "Form Factors of Beams Subjected to Transverse Loading Only," Forest Products Laboratory, Madison, Wis.

⁴ J. B. Johnson, "The Materials of Construction," John Wiley and Sons, p. 51 (1898).

1(b). The section which was plane before loading will therefore be distorted by shear as shown by Fig. 1 (c) and the combined displacement due to both shear and bending is shown by Fig. 1 (d). This last curve represents the total strain accumulating in each fiber from the center of the beam, where there is no displacement because of symmetry, to the section X-X. This indicates that the section is warped by shear so that the tensile stress in the outer fiber is greater than it would be if the stress variation in the section were linear. Frocht's investigation⁵ indicates that in the case of Bakelite beams under center load, the neutral axis shifts at the load point and the tensile stresses are actually lower for very short beams than the straight line theory would indicate but the compressive stress is increased. This action would reduce the strength of a timber beam because the initial failure is usually in compression.

This warping of the tension side of the section is evident in Fig. 6 of Mr. Dietz's paper, showing that a similar action takes place when two symmetrically placed loads are used instead of the center point load. The warping of the sections of the beam between the load and the support causes a distortion of the sections between the loads where the total shear is zero. This causes an increase in bending stress. This condition is shown photoelastically in Frocht's "Photoelasticity" Fig. 6.35, page 208.^{5a} It should be noted that a uniformly loaded beam is not affected in the same manner, because the shear is zero where the maximum bending moment occurs.

The shearing distortion of the compression side of the beam which accounts for the curvature observed by Dietz is also explained by photoelastic tests of beams under concentrated loads. Shear stresses in the neighborhood of the loads are several times higher than those calculated by the formula based on parabolic distribution. Also the stiffness of timber perpendicular to the grain is comparatively low and the concentration of pressure under the loading blocks would cause considerable disturbance. These two factors could produce local strains which would reduce the horizontal strains in the compression side between the loads as indicated in Fig. 6 of Mr. Dietz's paper. The effect is somewhat similar to that of deep notches cut in the top of the beam at the load points.

Another point which has caused some confusion is the observation that the proportional limit is higher in bending than in direct compression. This is, however, also true of other materials⁶ and is due to the fact that when the extreme stress in a beam passes the yield point, the greater part of the beam is still at lower stress, whereas in a direct compression test it all reaches the yield point at the same time.

The Bach-Baumann theory is the same as that of Saint Venant⁷ and assumes the same relation between stress and strain as in the case of direct compression and tension. At failure, the compressive strain at the extreme fiber in a beam is much greater than that associated with the maximum strength in direct compression, which indicates

that the maximum stress at that time is not at the extreme fiber but well within the beam. Calculation of the moment of resistance of a beam based on the Saint Venant theory shows that the maximum moment is reached after the compressive stress in the extreme fiber has passed its maximum. The maximum moment calculated in this way appears to be in good agreement with test results. This theory also applies satisfactorily to reinforced concrete.⁸

By means of this theory it appears possible to calculate the maximum moment for beams of different shape as accurately as it can be done by any other method of determining the form factors. The individual variations in the material are so great that no method can be very accurate. Among other variables is the influence of position of the annual rings because of the difference in the shearing stiffness of the spring and summer wood. Edge grain material will behave somewhat differently than that cut tangent to the rings.

The writer can find nothing to justify the Newlin-Trayer theory that more highly stressed fibers are stiffened and supported by the less stressed fibers nearer the neutral axis. On the contrary, the load appears to be transferred from the outer fibers, as they become overstrained, to the less strained fibers toward the neutral axis just as in the case of other materials. There is therefore no reason to think that the individual fibers behave very differently in flexure than they do under direct stress. Because of the use of empirical values, this theory, of course, gives results in reasonable agreement with the tests on which it is based. However, if the theory is not fundamentally correct it is not safe for general application.

There is great need of more information on the effect of shear stresses on the strength of beams under varying conditions of load. Present formulas are not adequate to predict the strength of beams under uniform loads or concentrated loads in different positions, or to predict the effect of cracks or notches.

A program of research might include photoelastic analysis of laminated models of alternate layers of plastic of different moduli of elasticity to simulate the effect of the low shearing modulus of wood. It also might be possible to study the strains in a wooden beam by cementing a thin sheet of plastic to the side. If the fundamental theory is properly developed, large laminated glued flexural members could be designed and used with more confidence.

Closure by Mr. Albert G. H. Dietz:⁹

The discussion by Mr. Whitney is welcomed as a different explanation of the phenomena noted in the author's paper on "Stress-Strain Relations in Timber Beams." The behavior of timber, a nonisotropic material, still needs much study and analysis, particularly, as Mr. Whitney points out, in view of its increasing use in laminated members of considerable depth and span.

The Newlin-Trayer fiber-aid theory with its accompanying form factors and depth factors has been the subject of considerable discussion pro and con. The phenomena presented in the paper can be, and are, interpreted to

⁵ M. M. Frocht, "Photoelastic Investigation of Shear and Bending Stresses in Centrally Loaded Simple Beams," *Engineering Bulletin* 76, Carnegie Institute of Technology, p. 16, Fig. 15.

^{5a} M. M. Frocht, "Photoelasticity," John Wiley and Sons, Vol. 1.

⁶ S. Timoshenko, "Strength of Materials," Vol. II, p. 373.

⁷ "Saint Venant's notes on Navier's Book 'Résumé des leçons . . .,'" Third Edition, p. 173 (1864).

⁸ Charles S. Whitney, "The Plastic Theory of Reinforced Concrete Design," *Transactions, Am. Soc. Civil Engrs.*, Vol. 107, p. 251 (1942).

⁹ Assistant Professor, Department of Building Engineering and Construction, Massachusetts Institute of Technology, Cambridge, Mass.

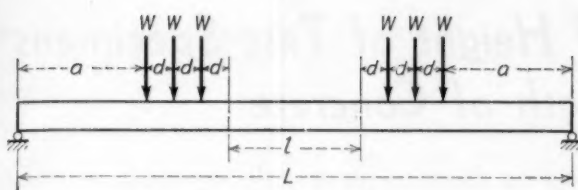


Fig. 2.

substantiate that theory, but no dogmatic stand is intended. Certainly any apparent deviation from a plane section in a portion of a beam in which ostensibly no shear exists must be carefully considered.

Mr. Whitney makes the suggestion that because timber possesses a low modulus of rigidity in the direction of the grain, shearing distortions extend into the central portion of a simply supported beam symmetrically loaded at two points and cause plane sections to be warped into the form noted. He assumes this to be true in spite of the fact that this portion of the beam is subjected to pure bending. This suggestion has been made by others, but photoelastic studies such as those quoted by Mr. Whitney and similar ones made preliminary to this research indicate that shearing distortion as a matter of fact disappears very quickly in the vicinity of the load, and that a condition of uniform bending is soon established.

Nevertheless, to investigate possible shearing effects in regions of uniform bending, a series of tests was conducted in connection with recent investigations of laminated beams subjected to two-point loads. As shown in the accompanying Fig. 2, the beams were symmetrically loaded three different times, the distance a to each load W being increased successively an amount d equal to the height h of the beam until the final loads were applied at the third-points. Loads were carried to the bending proportional limit as indicated by load-deflection measurements. Two sets of deflection readings were taken at the center of the beam, one for the full span L , and one for a short span l completely within the region of uniform bending. The points of application of the loads W were therefore $3d$, $2d$, and $1d$ from the end points of span l .

In the distance a , shear distortion, as indicated by Mr. Whitney, causes the deflection to increase. Consequently, over the entire length L the apparent bending modulus of elasticity actually includes the shear distortion and is lowered accordingly. Furthermore, it is a variable depending upon the position of the loads. Between the loads W there should be no shear distortion, the deflection over the length l should, therefore, reflect the true bending modulus of elasticity and should not be affected by the position of the loads. If shear distortion extends beyond the loads W into the central portion of the beam, it should affect the deflection in that portion, should consequently be reflected in the observed bending modulus of elasticity, and its effect should be more marked as the load approaches the ends of the short span l .

In the tests, the over-all or apparent bending modulus of elasticity did vary, as expected, with the position of the loads, indicating that shear distortion affected the total deflection. The bending modulus of elasticity observed over the short span l was unaffected by the position of the loads. It was, of course, higher than the over-all or apparent modulus of elasticity, and higher by an amount

roughly corresponding to a modulus of rigidity approximately one-twentieth the true bending modulus of elasticity.

From the foregoing tests it was concluded that shear distortion, caused by the external loading, did not extend into the region of uniform bending, in a beam loaded in this manner, a distance greater than the depth of the beam.

The further conclusion does not necessarily follow, of course, that the Newlin-Trayer theory is absolutely confirmed, but some explanation other than ordinary shear-distortion must apparently be found to account for the observed distortion of the strain curve of Fig. 6 in the paper. Interaction of the fibers, the tendency of highly compressed individual fibers to buckle, was thought to cause an internal condition analogous to shear, but not shear in the usual sense, which could cause distortion of the strain curve. Whatever explanation is offered must also account for the diminution of outermost compression strains relative to the outermost tension strains. (Shear distortion would require equal changes in strain and would require the strain curve to be the same on the compression and tension sides.) Perhaps most important of all, a complete explanation must account for the absence of hysteresis in any fibers at any point in the beam until the bending proportional limit is reached, at which time all fibers simultaneously exhibit a hysteresis effect.

Mr. Whitney's suggestion that photoelastic studies be made on members laminated with transparent materials of different moduli of elasticity has been under consideration for some time, but difficulties of achieving absolute bonds and avoiding internal strains in the material have seemed rather formidable. The attempt would be worth making, however. The use of thin sheets of plastic or, perhaps still better, brittle varnish coatings on the wood, might also be helpful. The latter have been successfully employed in other connections.

Undoubtedly, considerable research is still required completely to analyze the behavior of timber under various loading conditions.

Twentieth Anniversary of Palestine Testing Laboratory

THE JANUARY-FEBRUARY, 1943, issue of the *Journal of The Association of Engineers and Architects in Palestine*, at Tel Aviv, is an anniversary number commemorating the 20 years of service of the Laboratory for Testing Materials. The issue includes the various talks presented at the exercises, including the remarks of the president, greetings from the Army, and from the Director of War Production and Controller of Heavy Industries who referred to the laboratory's work in testing of materials, performance testing, and research work. Also published is an article dealing with the activities of the laboratory by its director, A. Arnstein, who has been an A.S.T.M. member for a number of years. He describes the work on soils, metals, stones, concrete, asphalt, paints, water, etc., and stated, "All the tests mentioned above are made in accordance with standards of the British Standards Institution or those of the American Society for Testing Materials with both of which the Laboratory has been in constant touch for many years. Only where such standards are not available are the tests made on other lines, including some developed by the Laboratory itself, the reliability of which has in many cases now been definitely established."

Discussion of Paper on Effect of Height of Test Specimens on Compressive Strength of Concrete¹

Submitted by Mr. F. N. Menefee:²

Mr. Johnson's tests form a valuable addition to the information already available on the matter of the compressive strength of concrete test specimens as a function of the ratio of height to diameter, where the ends of the specimen meet with the usual restraint against transverse expansion by reason of the friction between the specimen and the testing machine head or platform.

Mr. Roy W. Crum has added the suggestion "if the specimens could be tested without this (horizontal) restraint (at the ends) it might make some difference in the results." Mr. Crum is correct in his surmise. It is probable that if all the tests that have been run in the study of the effects of variations in b/d were to be run over again with perfectly lubricated end conditions, we might get a smaller variation in the strength ratio between $b/d = 1\frac{1}{4}$ and $b/d = 3$. It is the writer's belief, if the ends were perfectly lubricated, that the curve in Fig. 1 of Mr. Johnson's paper would be flatter between $b/d = 1\frac{1}{4}$ and $b/d = 3$ and would remain approximately at the value given by the 100 per cent ordinate, but that the actual strength represented by the 100 per cent ordinate would be less. In fact the results of tests for any b/d , however small, are likely to be less where the ends are well lubricated.

The reason for this lies in the well-known weakness of concrete in tension—or in this case the equivalent tensile or cohesive strength. Although we are discussing a concrete specimen in compression, it is well to remember that there is no such thing as a compression failure. Failure will come through shear strain on planes approximately 45 deg. to the axis of loading or by diametral strain such as would be caused by diametral tension if there were a diametral force pulling radially outward.

Let the accompanying Fig. 1, $abcd$, represent a cylinder of concrete before being subjected to compression. Then $a'b'cd'$ will represent the cylinder after compression, provided surfaces ab and cd are allowed to expand in accordance with Poisson's ratio, without restraint from radial friction.

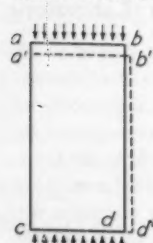


Fig. 1

This free expansion can be approximated by capping the ends with neat cement or plaster of paris smoothed with the usual glass plate and then coating with wax. With this preparation, the expansion per unit of diameter from top to bottom will be from 0.12 to 0.15 of the shortening per unit of height, assuming Poisson's ratio for concrete to fall between those limits. Taking the value of E for concrete to be 2,500,000 psi. in both tension and compression, and Poisson's ratio to be 0.12 a compressive stress of 2500 psi. will produce a compressive strain of 0.001 in. The cor-

responding diametral strain will be 0.00012 in. which is equivalent to a tensile stress of 300 psi., an amount which will probably exceed its cohesive strength. Tensile stress may not exist but plus diametral strain does, and it is by strain that cohesive failure occurs.

Under the above assumptions the compressive resistance is 2500 psi., the shear stress is 1250 psi., and the diametral strain is that which would take place if there were a transverse tensile stress of 300 psi. Should the shearing resistance be, say, 1260 psi., it is possible that the failure would be in the form of vertical cracks from top to bottom of the specimen. If perfect lubrication could be obtained, that is, no lateral restraint due to friction at the ends, the diametral expansion would meet with no resistance and failure by insufficient cohesive strength would result with little or no variation from changes in b/d up to possibly a value of 8; and the load which the cylinder would carry would be more nearly the correct total strength of the cylinder.

In the accompanying Fig. 2 we have the condition which obtains in the usual test, the horizontal arrows indicating frictional force. Dimensions ab and cd are restrained from expanding to the values $a'b'$ and cd' of Fig. 1. This end restraint diminishes to some lesser amount halfway between the top and bottom and the specimen in Fig. 2 will become barrel shaped. The greater the ratio of b/d the greater the diametral strain ef .

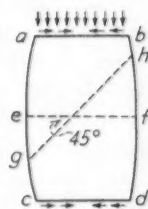


Fig. 2

With friction at the ends and where b/d is less than 1, not only is the barrel effect greatly reduced, thus reducing diametral strain and possibility of failure by exceeding the cohesive resistance, but the diagonal shear stress, that is, movement along the diagonal lines in the accompanying Fig. 3 in the direction of the diagonal arrows is restricted to a greater degree than would be the case along the diagonal gb in Fig. 2.

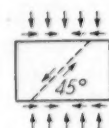


Fig. 3

Thus for specimens with friction at the ends and b/d less than 1, we have two conditions arresting failure. Lateral expansion and diagonal strain are both checked, the result being a higher load at failure. With b/d greater than 1, the diagonal strain is less restricted by the friction at the ends and is only limited by the amount of expansion along the diameter at ef in Fig. 2, which in turn is still restricted by the end friction, but in lesser amounts as b/d becomes greater. When b/d approaches 3, the effect of friction at the ends becomes almost nil at the diameter ef in Fig. 2, and ef expands as it would do if the ends were frictionless and failure begins by diametral strain along ef at a load corresponding to that which would produce diametral strain failure in a specimen of any ratio b/d lubricated at the ends.

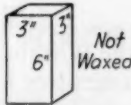
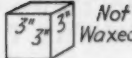
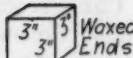
The foregoing analysis indicates that the minimum compressive strength of concrete specimens may be ob-

¹ James W. Johnson, "Effect of Height of Test Specimens on Compressive Strength of Concrete," ASTM BULLETIN, No. 120, January, 1943, p. 19.

² Professor of Engineering Mechanics, University of Michigan, Ann Arbor, Mich.

rained by waxing the ends of the specimen and the question of b/d may be eliminated if for any reason that is desirable.

The first and second columns in the following tabulation of test results on 42 concrete specimens tested in the Materials Testing Laboratory at the University of Michigan corroborates to a reasonable extent Mr. Johnson's results. The third column shows the results where the ends were waxed. The failures under these conditions were all by vertical cracking. The failure recorded in the first and second columns were by diagonal shear, but had the ends been waxed the results would have been practically the same as those in column 3, both in amount and type of failure.

			
	Compressive Strength, psi.	Compressive Strength, psi.	Compressive Strength, psi.
Specimen			
1.....	1930	2150	677
2.....	1560	1790	623
3.....	1516	2480	889
4.....	1136	1239	844
5.....	1527	2640	1160
6.....		2333	1550
7.....	1787	2440	667
8.....	1746	2240	1030
9.....	1778	2300	637
10.....	1633	2082	1378
11.....	1720	1800	1090
12.....	2100	2640	1740
13.....	2380	1940	945
14.....	2280	2740	1250
Average	1776	2201	1031

Discussion of Report of Air-Permeability Method for Determining Fineness of Cement

EDITOR'S NOTE.—This is a discussion of a report of the Working Committee on Fineness, of A.S.T.M. Committee C-1 on Cement, as published in ASTM BULLETIN, No. 118, October, 1942, p. 31. The report was prepared at the National Bureau of Standards under the direction of P. H. Bates, Chairman of the Working Committee.

The purpose of the investigation was to determine: (1) The porosity to which the cements should be compacted; (2) The amount of variation of surface area values as obtained by different laboratories both when using a constant pressure across the apparatus and by using a constant rate of flow through the apparatus; (3) The "index of compaction" as proposed by the U. S. Bureau of Reclamation; and (4) The variations obtained by different operators when using a constant weight to compress the samples of cement.

A paper has been submitted by the National Bureau of Standards entitled "A Simplified Air-Permeability Fineness Apparatus," by Raymond L. Blaine which continues this study. This paper appears in this A.S.T.M. BULLETIN, see page 51.

Submitted by Mr. P. J. Rigden:¹

Having regard to the various sources of error which can enter into comparisons of tests on cement samples carried out in different laboratories, for example, calibration differences, personal factor of operator, etc., the agreement between the laboratories recorded in the report is very satisfactory.

I think, however, that the systematic increase in surface area found when the porosity of the bed is steadily decreased is a matter for some concern. We have used the Lea and Nurse method in this laboratory for some time in work on fillers for bituminous surfacing materials and have no real evidence of this effect. Numerous tests have been carried out on various types of mineral filler in finenesses from 1000 to 20,000 sq. cm. per g. You are no doubt

aware that Carman² found, using liquids, that the permeability-porosity relation was true over a very wide range. One might, of course, expect differences when using air but I should have expected if anything the reverse effect to have been obtained.

I suggest that the fault lies not in the Lea-Nurse equation but in the method of compacting the bed for test. In a paper published recently³ I have discussed the question of nonuniformity in beds of powder and suggested a "step" method of building up the bed which to a large extent eliminates channelling and bridging, and longitudinal and radial nonuniformity.

The fact that so many laboratories have obtained similar values at various porosities by adhering to the standardized conditions as laid down shows that compaction in one operation is capable of giving reproducibility by process of "standardized nonuniformity."

The degree of nonuniformity would be expected to rise with increase in the weight of powder under compaction and it can be easily shown that, in general, a layer of over-compressed material just under the plunger will cause an apparent rise in resistance to flow and hence a rise in apparent surface area.

A further possibility is that the high values obtained at low porosities are more nearly the correct values because at low porosities there is less risk of channelling and bridging (a condition which gives low value by a process of bypassing).

I think it is a pity that this method which has the merit of speed and simplicity in operation should be complicated by correction factors which may not be necessary and which in any case may vary from one material to another.

I should appreciate your comments on these suggestions.

² Carman, P.C. *Journal of the Society of Chemical Industry* (London), Vol. 57, July, 1938, p. 230.

³ P. J. Rigden, "The Specific Surface of Powders. A Modification of the Air-Permeability Method for Rapid Routine Testing," *Journal of the Society of Chemical Industry* (London), Vol. 62, January, 1943, pp. 1-4.

¹ Road Research Laboratory, Department of Scientific and Industrial Research, Harmondsworth, West Drayton, Middlesex, England.

Submitted by Mr. F. M. Lea:⁴

I have recently seen the report of the Working Committee on Fineness of the A.S.T.M. Committee C-1 on Cement, and since you invite comment, I should like to submit the following notes for consideration:

The test results show an apparent increase in specific surface as the porosity is decreased, and it is proposed to correct this by changing the term $14/P(1 - E)$ in the equation to $14/P(0.85 - E)$.

There are, I think, objections to this, on two grounds, one experimental and the other theoretical.

1. We have encountered the apparent variation of specific surface with porosity and another laboratory making comparative tests in collaboration with us also found variations of the same order as those reported in the ASTM BULLETIN. These tests were made with a depth of bed of 1.88 cm. It was considered that the main source of this variation probably lay in nonhomogeneity of the bed, and that one method of eliminating this would be to use a less deep bed. A series of tests were, therefore, made with $L = 1.00$ cm. The variation in specific surface with porosity over a range of porosity from 0.46 to 0.51 was within the limit of error of the method in the tests made here. The other collaborating laboratory also found that the apparent variation disappeared with the less deep bed. We also tested a sand of about 15 to 7.5 μ particle dimensions and, since this would be less likely to suffer from nonuniformity of the bed, we used $L = 1.88$ cm. Over a range of E from 0.496 to 0.561 there was no variation in specific surface outside the normal experimental error.

From this experience I am led to think that if, in the A.S.T.M. tests, beds of differing depth had been tried, it would have been found that the constant 0.85 varied with the depth of bed and that with suitably shallow beds it would have become equal to unity. There is the obvious disadvantage that if too low a depth is used, the error in forming the bed to a fixed depth increases. This can probably be overcome by forming the bed in steps⁵ but for a method which has the advantage of speed and simplicity I think there is much to be said for accepting a slightly increased error and using a depth which can be compacted homogeneously in one operation. Our results here indicate that $L = 1.00$ cm. fulfills these requirements for cements. For coarser powders a higher value of L would probably be desirable.

There is the further point that the range of porosities over which homogeneity can be assured is limited. The lowest porosity to which we find cements can be compacted at all readily by hand in a single layer is about $E = 0.46$, but for some cements this is too low, since at this porosity they give a certain amount of "spring" in the compacted layer, and we have found it advisable to standardize on $E = 0.475$. On the other hand, at too high porosities the risk of nonuniformity and of channelling and bridging exist since only a low force of compaction can be used. There is also the possibility that the passage of the air might disturb the bed.

It may be argued that the good agreement obtained in the A.S.T.M. tests between different laboratories indicates that homogeneous beds were obtained. This, however, I rather doubt, for a standardized procedure for compacting may quite readily produce a standardized non-uniform bed.

2. The introduction of the constant in the term $14/P(0.85 - E)$ is quite empirical. There seem to be cases in the passage of a fluid through a powder where a correction to E is required, because there may be a static layer of the fluid in contact with the surface. Thus Carman⁶ cites evidence that in the passage of water through clays a portion of the pore space adjacent to the solids is occupied by water bound so firmly as to be immobile. The effective pore space is then less than E . The correction for this appears, however, under the square root term of the equation and not in the $14/P(1 - E)$ term, since the $(1 - E)$ here is merely part of the conversion from specific surface per unit volume of bed to specific surface per unit weight of solid.

There is, so far as I am aware, no evidence that any such phenomenon occurs in the passage of gases through fine powders, though it is possible that it might enter when specific surfaces much higher than those of cements are reached and the capillary channels become of much smaller diameter. For powders of cement fineness the available evidence all supports the validity of the equation (see, for instance, the summary given by Sullivan and Hertel)⁶.

Perhaps I might add that when we first encountered the apparent variation of specific surface with porosity, using a bed with $L = 1.88$ cm., I tried the application of a corrected equation, as discussed by Carman for clay and water. Examination of this type of equation shows that a plot of $1/S_g^2$ against $1/E$ should be linear and from the intercepts on the axes the true specific surface, and the thickness of the immobile layer, can be deduced. Some apparently linear plots were obtained over a limited range of E values, but the derived specific surface values were improbably low. The data for cement No. 1 in Table I in the ASTM BULLETIN gives a curved plot when treated in this way. Later the use of a bed with $L = 1.00$ cm. eliminated the variation and thus showed the attempt to treat the earlier data by amending the equation was based on an erroneous premise, and that the apparent linear relation obtained was misleading.

To sum up my argument, I think one should hesitate before abandoning the original equation which is based on the work of Kozeny and Carman and supported by a considerable body of evidence, and be quite sure that the conditions of formation of the bed are such that the homogeneity required for the equation to be applicable is obtained.

I should be interested to be kept in touch with your later developments, for if, as seems likely, the air permeability method is to come into general use it will be all to the good if variations in detail, or in the treatment of the data, can be avoided so far as is possible.

⁴ Building Research Station, Department of Scientific and Industrial Research, Garston, Nr. Watford, Herts, England.

⁵ Carman, P.C. *Journal of Agricultural Science*, Vol. 29, Part II, p. 262 (1939).

⁶ Sullivan and Hertel, "Advances in Colloid Science," Vol. 1, edited by E. O. Kraemer, Interscience Publishers, Inc. (1942).

A Simplified Air Permeability Fineness Apparatus

By Raymond L. Blaine¹

SYNOPSIS

A new apparatus has been designed for measuring the fineness of granular materials by means of the air permeability method. The new apparatus is analogous to the U tube viscometer in which the liquid in the U tube provides the pressure difference and also serves to indicate the volume of flow. The apparatus is inexpensive, simple both to make and to operate, and requires practically no critical materials.

The results of tests with portland cements indicate that the fineness values obtained are reproducible and are in agreement with values obtained with the Lea-Nurse type air-permeability apparatus.

THE THEORY OF THE permeability method for determining the fineness of granular materials as well as descriptions of the various instruments using this method (1, 2, 3, 4, 5, 6, 7, 9, 10)² have been discussed in previous publications. Comparative tests by 20 laboratories using the Lea-Nurse type air-permeability fineness apparatus which were reported in the October, 1942, ASTM BULLETIN (10) indicated that there was a need for a standard fineness sample to furnish a reference value by which the "personal equation" and errors of measuring the constants of the apparatus may be corrected. A new apparatus was designed which is inexpensive, simple both to construct and to operate and necessitates the use of practically no critical materials. Although designed primarily as a comparative instrument, it is a complete fineness apparatus in itself in that calculations of specific surface can be made from measurements of the constants of the instrument. The basic design is analogous to the U tube viscometer (13).

After the experimental work (reported in this paper) was completed, a publication (11) describing a Modified Lea-Nurse fineness apparatus was received. Although developed independently, the present design and that developed by Rigden (11) are practically identical. The tests reported in this article may, therefore, be considered as confirming the possibilities of the use of this type of apparatus for fineness control work.

APPARATUS AND TEST METHOD

A diagram of an apparatus used for the tests here reported is presented in Fig. 1. The permeability cell was made from 15-mm. glass tubing. The tubing was constricted and an inside ledge was ground at the constriction by means of a metal tube slightly smaller than the inside diameter of the cell, using fine carborundum and water as the grinding medium. This operation also served to grind the cell to a uniform inside diameter. A $1\frac{1}{32}$ -in. brass disk perforated with closely spaced $\frac{3}{64}$ -

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia 2, Pa.

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² The italic numbers in parentheses refer to the reports and paper, appearing in the list of references appended to this paper.

in. holes was made to fit the inside of the cell snugly and rest on the ground ledge. The plunger used to compact the cement was made of Bakelite and compacted the cement to a bed depth of 1.47 cm. In one series of tests the U tube was half filled with Stanolax, a light mineral oil of low vapor pressure, and in another series, *n*-butyl phthalate was used.

Values of h_1 and h_2 and of the diameter of the permeability cell were determined by means of a cathetometer. The h_2 values were obtained for tube drainage periods of 1 to 5 min. and at both 21 and 38 C. The density of manometer fluid was determined at the two temperatures by means of a pycnometer. The volume of the bed of cement was determined from the difference between the amounts of mercury necessary to fill the cell before and after preparation of a bed of powder. The volume of the U tube between marks B and C was determined by filling from a burette.

In operation the brass disk was placed on the ground ledge in the permeability cell and on top of this a filter paper disk of the same diameter as the inside of the cell. A weighed quantity of cement was placed in the cell, consolidated and leveled by tapping the cell. Another fil-

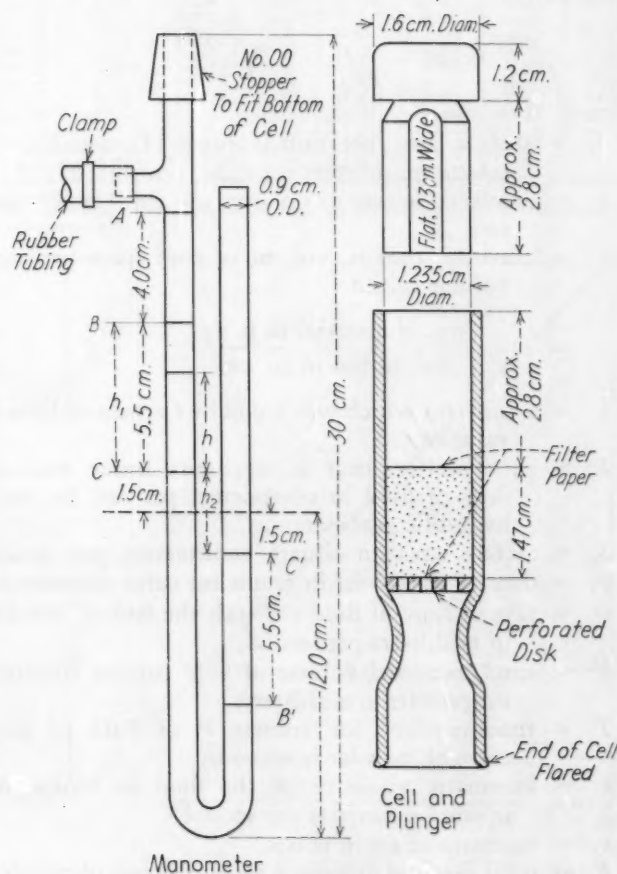


Fig. 1

ter paper disk was then placed on top of the powder and the powder compacted by means of the plunger to a depth controlled by the plunger collar. The bottom of the permeability cell was then attached to the rubber-stoppered arm of the U tube, first moistening the rubber stopper. Air of the one arm of the U tube was removed through the glass tee and rubber tube until the liquid of the U tube was at *A*. The rubber tube was then clamped and the time required for the level of the liquid to fall from mark *B* to mark *C* noted. The difference in level of the liquid in the manometer arms supplies the pressure difference across the bed of powder and also serves to indicate the volume of air passing through the sample.

THEORY

Carman's equation relating specific surface to permeability is as follows

$$S_0 = \sqrt{\frac{g}{kKv} \cdot \frac{e^3}{(1-e)^2}} = 14 \sqrt{\frac{1}{Kv} \cdot \frac{e^3}{(1-e)^2}} \quad (1)$$

where Carman defined

$$Kv = \frac{QnL}{AP}$$

If then we let $S_w = S_0/p_1$

and $Q = V/T$,

and \bar{P} = the mean effective pressure across the bed of powder, which corresponds with the constant pressure *P* of Carman's equation

then we get

$$S_w = \frac{14}{p_1(1-e)} \sqrt{\frac{e^3 APT}{VnL}} \quad (2)$$

where:

S_0 = surface area per unit volume of particles, in square centimeters per cubic centimeters;

g = acceleration due to gravity, 980 cm. per sec. per sec.,

e = porosity, that is, volume of pore space per unit volume of bed

$$= 1 - \frac{(\text{wt. of material in g.})/p_1}{\text{vol. of bed in cu. cm.}}$$

k = a constant which was found by Carman to have a value of 5;

K = permeability, that is, apparent linear rate of flow of fluid in centimeters per sec. for unit hydraulic gradient;

S_w = surface area in square centimeters per gram;

p_1 = density of powder in grams per cubic centimeter;

Q = rate of flow of fluid through the bed of powder in milliliters per second;

V = total measured volume of fluid passing through the powder in milliliters;

T = time required for volume *V* of fluid to pass through powder in seconds;

v = kinematic viscosity of the fluid in Stokes in square centimeters per second;

n = viscosity of air in poises;

P = total pressure difference across the bed of powder in grams per square centimeters;

\bar{P} = mean effective pressure difference across the bed of powder in grams per square centimeters;
A = area of bed of powder in square centimeters;
and

L = depth of bed of powder in centimeters.

The pressure difference across the bed of powder was held constant in both the Carman and in the Lea-Nurse apparatus. In the U tube apparatus the pressure difference across the bed of powder, which is caused by the difference in level of the liquid in the manometer arm, varies as the liquid in the manometer arms approach the equilibrium level. It can be assumed that the rate of flow of air through the powder is proportional to the pressure difference.

With the U tube fineness apparatus, where the fall of the liquid in one arm determines the volume of air passing through the sample, it is desirable to express the mean pressure in terms of the one manometer arm. Where no externally applied pressure is employed, the equation most commonly used³ to express the mean effective head is as follows:

$$H = \frac{H_1 - H_2}{\log_e (H_1/H_2)} \quad (3)$$

where:

H = mean effective head,

H_1 = initial head, and

H_2 = final head.

In terms of the apparatus under consideration (see Fig. 1),

the final pressure, $H_2p = (CC')p = b_2p$,

where *p* is the density of the liquid, and

the initial pressure $H_1p = (BC + CC' + C'B')p = 2b_1p + b_2p$

Substituting these values in Eq. 3 the mean effective pressure

$$\bar{P} = \frac{2b_1p}{\log_e (1 + 2b_1/b_2)} \quad (4)$$

or in terms of common logarithms

$$\bar{P} = \frac{0.8686b_1p}{\log_{10} (1 + 2b_1/b_2)} \quad (5)$$

Substituting this equation in Eq. 2

$$S_w = \frac{14}{p_1(1-e)} \sqrt{\frac{e^3 AT \cdot 0.8686b_1p}{VnL \log_{10} (1 + 2b_1/b_2)}} \quad (6)$$

Lea and Nurse expressed the specific surface in terms of apparatus constants as

$$S_w = \frac{14}{p_1(1-e)} \sqrt{\frac{e^3 Ab_1'}{CLb_2'}} \quad (7)$$

³ Barr (13) refers to the derivation of the formula by Koch (14). The value of the mean head was also later derived by Meissner (15), Simeon (16), Bingham, Schlessinger, and Coleman (12), and Lidstone (17), and has been discussed by other authors as well.

where:

- C = a constant for the flowmeter,
- b'_1 = difference in level of liquid in manometer measuring pressure difference across the bed of material, and
- b'_2 = difference in level of liquid in manometer measuring pressure difference across the capillary.

However, in tests on a number of portland cements (10) it was found that in order to obtain the same specific surface values at different porosities it was necessary to use the formula

$$S_x = \frac{14 \times 0.850}{p_1(0.850 - e)} \sqrt{\frac{e^3 A b'_1}{C L b'_2}} \dots \dots \dots (8)$$

where S_x equals corrected specific surface. Inasmuch as comparisons were made of cements tested at different porosities a corresponding formula was used with the U tube apparatus

$$S_x = \frac{14 \times 0.850}{p_1(0.850 - e)} \sqrt{\frac{e^3 A P T}{V n L}} \dots \dots \dots (9)$$

For routine analyses and control purposes where the density of the powder is the same and a constant weight of powder is compacted to some definite porosity, or in other words if the quantities p_1 , e , A , P , V , n , and L of Eq. 9 are constant, the equation becomes

$$S_w = K \sqrt{T} \dots \dots \dots (10)$$

where K is a constant.

If the apparatus is not operated at a constant temperature a number of variables enter into the equation. The effect of the difference in viscosity of air at different temperatures can be corrected for by using the equation

$$S_w = K_1 \sqrt{T/n} \dots \dots \dots (11)$$

where K_1 is a constant.

When a fixed quantity of fluid is used in the manometer, the temperature of test also affects the density and, therefore, also the volume of the fluid used. With fixed timing marks, the b_2 value depends on the temperature and this affects also the calculated mean pressure. The correction for difference in b_2 with temperature is as great as the correction for viscosity of air, and would be influenced by the ratio of the total amount of fluid in the manometer to the diameter of the manometer arms. One other factor which must be considered is that of the drainage of the manometer arms. This affects both the volume of air going through the bed of powder and the b_2 value of the manometer. However, one factor compensates for the other to some extent. A correction can be made for the effect of the difference in weight of the air columns above the manometer arms on the calculated mean pressure, but at the relatively low pressure head of this type of apparatus this correction would be small.

TESTS

Fineness determinations were made on 16 samples of cements by means of the Lea-Nurse type apparatus. The capillary constant of the apparatus was 2.08×10^{-6} . The tests were made on 14-g. samples compacted to a porosity of 0.532 in a 1-in. diameter cell. These tests

were made at room temperature of about 25 C. Fineness determinations were also made on the same cements using the U tube apparatus at 21 C. and 38 C. The tests were made on 2.4-g. samples compacted to a porosity of 0.513 in a 1.21-cm. diameter cell. Duplicate determinations were made in each case. A series of tests were made at room temperature on 2.7-g. samples compacted to a porosity of 0.513 in a 1.235-cm. diameter cell.

Each of twenty-two compacted beds of one sample of cement were tested on both the U tube apparatus and the Lea-Nurse type apparatus.

The temperatures of test for any one series were held to within a range of 2 C.

RESULTS OF TESTS

The specific-surface values of the 16 cements were calculated from the constants of the U tube apparatus at the two temperatures. In these calculations account was taken of the difference in the viscosity of the air and the difference in mean pressures as well as the effect of tube drainage on the volume of air passing through the sample. The average percentage by which the specific-surface

Table I.—Specific Surface and K Values for 16 Cements.

Cement	S_x , sq. cm. per g. ^a	S_x , U Tube, 21 C., sq. cm. per g. ^b	S_x , U Tube, 38 C., sq. cm. per g. ^b	K (21 C.) ^c	K (38 C.) ^c	S_x , sq. cm. per g. ^d	
						21 C.	38 C.
No. 1	3620	3640	3620	6.88	6.81	3620	3660
No. 2	3640	3610	3630	6.96	6.82	3600	3670
No. 3	3710	3760	3740	6.82	6.75	3740	3780
No. 4	3860	3880	3880	6.87	6.76	3870	3930
No. 5	4000	4030	4010	6.86	6.78	4010	4060
No. 6	4070	4060	4040	6.92	6.84	4050	4090
No. 7	4120	4130	4070	6.99	6.88	4120	4120
No. 8	4130	4170	4130	6.84	6.81	4150	4180
No. 9	4270	4310	4270	6.84	6.76	4290	4350
No. 10	4460	4430	4420	6.95	6.86	4420	4480
No. 11	5730	5740	5630	6.89	7.03	5720	5620
No. 12	5960	6000	5800	6.85	6.98	5980	5880
No. 13	6290	6280	6120	6.92	7.00	6260	6180
No. 14	6410	6470	6250	6.84	6.98	6450	6320
No. 15	6510	6540	6400	6.87	6.93	6520	6470
No. 16	6770	6840	6690	6.84	6.88	6810	6770

- ^a S_x determined by means of the Lea-Nurse apparatus (Eq. 8).
- ^b Calculated from the constants of apparatus (Eq. 9).
- ^c S_x determined by Lea-Nurse apparatus divided by $(T/n)^{1/2}$ determined on U tube apparatus.
- ^d S_x calculated from average K value (6.88) times $(T/n)^{1/2}$ determined on U tube apparatus.

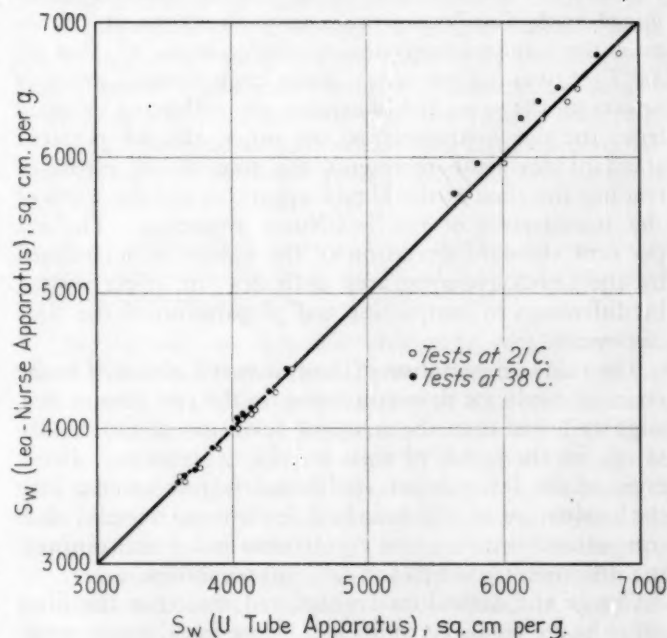


Fig. 2

values calculated from the 21 C. tests on the U tube differed from the values obtained with the Lea-Nurse type apparatus at 25 C. was 0.6 while at 38 C. the average difference was 1.1 per cent. The relation of these calculated U tube values to the values obtained with the Lea-Nurse apparatus is presented in Fig. 2 and Table I. As can be noted in this figure and table, the greatest divergence between the two methods occurred at 38 C. with the finer cements.

In order to test the practicability of the use of the shorter formula (Eq. 11), calculations were made of the relation of the Lea-Nurse values to the $(T/n)^{1/2}$ values obtained with the U tube apparatus. In the series of tests at 21 C. the average value of the constant $K_1 = S_w/(T/n)^{1/2}$ was 6.88 with a standard deviation of 0.73 per cent, while at 38 C. the average value of the constant was 6.87 with a standard deviation of 1.34 per cent. No correction was made for the difference in mean pressure caused by the differences of the b_2 values and the density of the manometer fluid.

In 22 determinations by means of the Lea-Nurse apparatus on one sample of cement, the standard deviation was 1.2 per cent. The specific-surface values obtained by means of the Lea-Nurse apparatus was divided by the respective $(T)^{1/2}$ value obtained on each of the compacted beds with the U tube apparatus. The average value of the constant, that is, $K = S_w/(T)^{1/2}$ obtained with the cell used was 526 with a standard deviation of 0.6 per cent.

DISCUSSION

It may be noted in Table I that the surface area values of the 16 cements calculated from the constants of the apparatus were about the same as the values calculated from the constant K_1 . This seems to indicate that the shorter formula can be used with cements at different temperatures even with the variations of mean pressure with temperature.

In the 22 determinations on the one cement, the standard deviation of the specific surface values as determined by the Lea-Nurse apparatus was 1.2 per cent. However, the standard deviation of the constant K , that is, $S_w(T)^{1/2}$, was 0.6 per cent. Since each determination of K was on the same bed of cement, the cell being changed from the one instrument to the other, the 0.6 per cent standard deviation represents the sum of the errors of reading the time of the U tube apparatus and the levels of the manometers of the Lea-Nurse apparatus. The 1.2 per cent standard deviation of the values as determined by the Lea-Nurse apparatus indicates the effect caused by differences in compaction and preparation of the beds of powder.

The standard deviation of the constant K obtained in the series of duplicate determinations on the one cement was slightly lower than the standard deviation of the K_1 obtained in the series of tests on the 16 cements. However, in the latter series, additional factors entered into the evaluation of the standard deviations, namely, that comparisons were made of results obtained from compacting different size samples to different porosities.

One of the difficulties encountered was that the filter paper had a tendency to buckle. Any buckling or wrinkling affects the porosity and, therefore, also the perme-

ability of the bed. The filter paper must be cut to exact size or only a thousandth inch or so oversize and should lie flat both above and below the sample.

Rigden found that more uniform results were obtained in air permeability tests by building up the bed of powder in 2-mm. steps. It appears, however, that he referred to tests of any one material at different porosities. However, this necessitates measuring the depth of bed in each test and making the longer calculation. Gooden (8) also used a similar increment method for compacting powders for air permeability tests. Comparative tests (10) have indicated difficulty in determining the exact porosity. There are more chances for error both in measuring and in calculating and considerably more time is required per test.

For routine test work it is desirable to make the test and the test method as simple as possible without sacrifice of reproducibility. It is believed that for comparative purposes it would be easier to standardize the porosity at which the tests are to be made and it is certainly more simple to calculate the fineness values if the powder is compacted in one operation to a definite bed depth.

The diameter of the U tube and of the cells used in this investigation were considerably smaller than the sizes suggested by Rigden who stated that for materials of the fineness of cement, the diameter of the U tube limbs should be 2 to 3 cm. with a permeability cell diameter of 2 to 3 cm. It was also recommended by Rigden that the time interval measured be at least 4 min. In the present investigation the time intervals measured ranged from 50 sec. to 3 min. The results of tests here reported indicate that the values obtained with the smaller U tube and cell and shorter testing time were satisfactory both as to reproducibility and agreement with values obtained with the Lea-Nurse type instrument. While it is recognized that the drainage factor of the U tube is of moment, this is partially compensated for by the fact that a smaller volume of air passes through the sample when the time interval is such that the drainage is not complete.

For control purposes the relative fineness of the product can be expressed in terms of the square root of the measured time interval. However, in order to obtain the fineness in terms of square centimeters per gram it is necessary to use either a standard sample of known density and specific surface or to determine the constants of the apparatus and the compacted bed. The U tube apparatus of the dimensions shown was designed primarily for use with portland cement and for calibration by means of the standard turbidimeter fineness sample No. 114. When materials of different densities, or, if different porosities are used with materials of the same density, it will be necessary to use the following formula:

$$\frac{S_w(\text{known sample})}{S_w(\text{unknown sample})} = \frac{\frac{K_2 \sqrt{e^3 T}}{p_1(1-e)} \text{ known sample}}{\frac{K_2 \sqrt{e^3 T}}{p_1(1-e)} \text{ unknown sample}}$$

where K_2 is a constant common to both known and unknown sample.

In this case it is necessary to determine the density of the powder in order to calculate the porosity to which the bed of powder is compacted, but it is not necessary to determine the actual b_1 and b_2 values, density of manome-

ter fluid, volume of air passing through the sample, depth, or area of the bed of powder. (The porosity can be determined by the displacement of mercury method described above.) However, other difficulties may be expected if one standard sample is used for different materials, since, as was pointed out in a previous publication (10), the value of the constant (0.850) as used in Eq. 8 for portland cements is not the same for all powders.

In testing other powders of different densities, fineness and compactibility, the various dimensions of the apparatus and of the bed of powder may have to be modified to suit the material tested. In designing an apparatus for such material, consideration should be taken of the drainage factor, the errors of weighing and preparation of bed, possible errors of reading of meniscus, and effect of possible air leaks at junction of cell and U tube and at the clamp.

SUMMARY

The simplified U tube air permeability fineness apparatus is very simple to construct and to operate. For routine work, the calculations are very simple as the relative fineness can be expressed in terms of the time required for the liquid in one of the manometer arms to fall a definite distance. The apparatus can be calibrated by means of a standard sample of known specific surface or the specific surface values can be calculated from the constants of the apparatus. The results of tests are reproducible and are in agreement with values obtained by means of the Lea-Nurse type air permeability apparatus.

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1944 Annual and Spring Meetings

THE EXECUTIVE COMMITTEE, after considering the various factors in connection with the 1944 Spring Meeting and A.S.T.M. Committee Week, and the Forty-seventh Annual Meeting to be held in 1944, has decided definitely to plan to have Committee Week in Cincinnati, Ohio, probably extending over several days during the week of February 28 to March 3, inclusive, with the Spring Meeting and its technical features on March 1. Several suggestions have been made of subjects which may be covered in individual papers or technical symposiums.

No definite decision was reached concerning the Annual Meeting, but the choice was first Atlantic City, provided hotel facilities can be made available (it is very unlikely that Chalfonte-Haddon Hall can be used because the Army Air Forces is maintaining it as a base hospital) and if adequate facilities cannot be made available, New York City would be the next selection.

In selecting Cincinnati for the Spring Meeting and Committee Week, the officers have in mind the industrial significance of this particular area, the fact that a number of active A.S.T.M. members are located in Cincinnati and its surrounding industrial area, and also to continue the policy of having these early March meetings held in different industrial areas. Probably all sessions will be at the Hotel Netherlands-Plaza.

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New Standing Committee on Industrial Aromatic Hydrocarbons

INVITATIONS are now being extended to a number of interested members of the Society to serve on a new committee on industrial aromatic hydrocarbons. This committee was authorized recently by the Executive Committee in response to a number of requests and suggestions that had been received that the Society undertake work in this general field which has assumed considerable importance in recent years. The proposed scope of this committee is as follows:

Scope.—Nomenclature, methods of test, and specifications for industrial aromatic hydrocarbons and related products boiling below 400 deg. Fahr. for other than fuel purposes.

The decision to organize this new committee was based upon recommendations from a special study group functioning under the chairmanship of R. P. Anderson to advise Committee E-10 on Standards and the Executive Committee of the Society. After thorough review of the field and the need for standards, the decision was reached that immediate steps should be taken looking toward the organization of a new A.S.T.M. standing committee. It is expected that it will get under way promptly and an announcement concerning the personnel of the committee will appear in the next issue of the *ASTM BULLETIN*.



AUGUST 1943

NO. 123

TWO-SIXTY
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What's Ahead?

IN ANY ORGANIZATION it is difficult to look very far into the future, although budgets and production plans, and the like, are essential. And in a volunteer organization it is all the more difficult to see just what is ahead, but the Society's officers, Committee E-10 on Standards, Committee E-9 on Research, and the executive personnel of the standing technical committees do devote time to developing information on what is planned. In this BULLETIN there is an article dealing with some projects imminent in the standardization field, that is, specific specifications and tests which are practically complete or nearing that phase; some others on which the objective will be reached in a relatively short time. In a forthcoming BULLETIN it is planned to publish a reasonably complete review of the large number of active A.S.T.M. research projects, which while not exactly work ahead do indicate investigations that are moving along to develop authoritative data on the properties and tests of materials. These too will be specific projects.

In early or late phases of the planning stage are several proposed new standing committees which always involve study and a careful evaluation of the opinions of those concerned with a particular problem, both from the standpoint of user and producer. Such projects already authorized include a new committee on industrial aromatic hydrocarbons—organization of this committee is under way. A special committee has met to study the best means of handling standardization work in the field of powder metallurgy, and recommendations will be submitted and a similar study will consider the field of adhesives. All three of these projects are extensive ones and there is much room for well-conceived standardization and research efforts. Another problem particularly pressing in some fields now involves that of magnetic powder inspection which a small group in the Steel Committee is studying.

Perhaps a concise answer to the question "What is ahead?" is not possible, but it is evident there are a great many problems where the Society can be of assistance and where through the activities of its technical committees much can be done.

The New President, Dean Harvey, Comments:

THE RECENT ANNUAL Meeting in Pittsburgh is another illustration that we belong to a remarkable Society. With a membership of about 4900, the registration at the Annual Meeting was 1452, almost a new record. About 245 committee meetings were held. There were 15 technical sessions in which were presented four addresses, 51 committee reports and 52 contributed papers dealing with materials and methods of testing. The meeting was devoted to the subject of materials and methods of testing as applied to the War Program, and much valuable work was done by the various committees.

There must be a realization by our members and friends that these activities are worth while, to cause them to take the time away from other important matters to attend meetings and participate in the work.

None of us can fully appreciate how much careful work is involved before an A.S.T.M. Standard is published by the Society. Included in this, under the sponsoring committee, are the gathering and evaluation of facts bearing upon the subject, deciding upon the requirements and putting them into standard form, involving considerable correspondence and research. Then the proposed standard is edited by the Headquarters Staff. The study of each standard is continued after publication, to keep it up to date in accordance with modern developments.

While a great many of our members are engaged in committee work, it is obviously impossible for all of us to take part in it. However, every member of the Society can help in some way, such as—

- Promoting the use of our standards;
- Offering suggestions for improving standards;
- Preparing papers and discussions on important subjects for the Annual Meeting, committee meetings and the ASTM BULLETIN;
- Participating in other Society activities;
- Telling others about the Society and thus obtaining new members;
- Participating in District Committee work.

The Society needs the loyal support of every member in order to carry on effectively the important work for which it is responsible.

PRESIDENT

Discussion of Annual Meeting Papers

WRITTEN DISCUSSION of the papers and reports presented at the 1943 Annual Meeting in Pittsburgh will be received by the Committee on Papers and Publications until September 1. However, all who plan to submit discussion are urged to send it to Society Headquarters as far in advance of this date as possible in order to facilitate preparation of material for the *Proceedings*.

Many comments are made on the value of discussion in bringing out the more salient features of technical papers, or in giving a somewhat broader or frequently a different viewpoint on the interpretation of the data in the original paper. Anyone who spends even a few minutes perusing the bound *Proceedings* cannot help but realize just what an important part of these technical books is the discussion. The Committee on Papers and Publications welcomes discussion by letter of any of the papers.

Numerous Actions on Standards Submitted to Members for Letter Vote

BY ACTION OF THE Forty-sixth Annual Meeting, 72 recommendations from standing committees were approved for submission to letter ballot of the Society membership. These recommendations cover 52 tentative standards proposed for adoption as standard and the adoption as standard of 20 revisions in existing standards.

In connection with this detail of standardization procedure, it should be noted that only by letter ballot of the entire Society membership can changes be made in the formal standards. The action of an annual meeting session alone, or in the interval between annual meetings Committee E-10 on Standards, can approve for publication as tentative proposed new standards, can approve revisions in tentative standards (which are incorporated immediately), or can take action to permit publication as tentative of proposed revisions in standards. Many such actions, of course, are taken at the Annual Meeting and throughout the year by Committee E-10.

A complete list of the items to be voted upon appears in the letter ballot being sent in a separate mailing to the members. Detailed information concerning most matters referred to letter ballot is given in the committee reports issued in preprint form to the membership in advance of the meeting. The *Summary of Proceedings* accompanying the letter ballot contains a record of all actions taken at the annual meeting and also gives in full detail any changes in or additions to the standing committee recommendations as preprinted.

The ballot will be canvassed on September 1 at which time all items receiving a favorable vote become effective.

All new and revised standards and tentative standards on which action was taken during 1943 will be published in the 1943 Supplements to the respective parts of the current Book of Standards. These three books will be published, it is expected, in November. Meanwhile, many of the items will appear in various special compilations of standards relating to specific industries and for the most part all will be available in separate pamphlet form.

Volume on Chemical Analysis Scheduled for Distribution in September

NOTES IN THE BULLETIN have indicated progress in the preparation of the 1943 Volume on Chemical Analysis of Metals which in one sense can be considered a fourth part of the Book of Standards. While on occa-

sion the progress may seem to have been slow, the committee in charge has been doing a very extensive job of clarification and simplification, and it has been necessary to take considerable time to resolve some of the major editorial problems involved. Now, however, the complete book is in type, the forms are being prepared for press, and it is hoped that the book can be printed and bound, and distribution started by the middle of September. Each member of the Society through the Members' Order Blank transmitted in September, 1942, had the opportunity to request without charge a cloth-bound copy of this book and to order additional copies at the special members' price of \$2 each. Those members who have requested this book and who have not received it by about November 1 might check with A.S.T.M. Headquarters to determine if their request was received and placed on file. Further details of the book will appear in the October BULLETIN.

New Committee on Metal Powders

PARTLY AS A result of the discussions incident to the Symposium on Powder Metallurgy held at the Spring Meeting of the Society, but more particularly to meet a demand that appeared to exist for standard test procedures and specifications in the field, a study is now being made of the advisability of organizing immediately in the Society a new standing committee on powder metals and powder metal products. In order to advise the Executive Committee in this matter, a study group has recently been appointed under the chairmanship of Vice-President J. R. Townsend. Considerations by this group would indicate the desirability of proceeding with organization of a new committee as suggested.

New Paper Stock for Bulletin

BEGINNING WITH this August ASTM BULLETIN and continuing indefinitely the BULLETIN is being printed on lighter weight paper stock, both the body and the cover stock having been reduced. This action has been taken in line with the spirit of conserving paper. It was felt that for the time being at least we should maintain the trim size of the BULLETIN. However the printer is able to use a somewhat smaller sheet which necessitates more careful planning of layout but also saves some paper over and above that saved by reduced paper weight. With the lighter paper, there should be no noticeable lessening in the quality of reproduction of illustrations.

... "The war is daily growing in scale and intensity. The consumption of war matériel will soon reach unheard-of proportions. . . . The distant goal of final victory is now visible, but no one can say how long it will take to reach that goal. The road ahead is rough and treacherous.

... "The men and women who are producing America's tools of war have it in their power to shorten the war by months. It is up to each of us to sustain his personal part in the war effort at his highest level, so that thousands of Americans whose lives might otherwise have to be sacrificed to win this war may return safely to their homes and families.

... "Personal ambitions and desires must be subordinated to the common cause. . . . Let's finish the job!"

—NELSON

New and Revised Tentative Standards Approved

THE SOCIETY ACCEPTED at the Annual Meeting 42 new tentative standards and revisions of 34 existing tentative specifications and methods of test. Of the new tentative standards 4 are supplements to existing standards—these are so indicated in the following list. Six of the 34 revised tentative specifications and test methods represent extensive modifications. The titles of these are included below (marked with an asterisk) with the list of those issued by the Society for the first time. Standing committees responsible for the various items are indicated in italics.

New and Revised Tentative Standards

Iron-Chromium-Nickel Alloys

(Committee A-10)

Recommended Practice:

Boiling Nitric Acid Test for Corrosion-Resisting Steels (A 262 - 43 T).

Corrosion of Non-Ferrous Metals

(Committee B-3)

Method:

Total Immersion Testing of Non-Ferrous Metals (B 185 - 43 T).

Electrical-Resistance Alloys

(Committee B-5)

Methods:

Test for Density of Fine Wire and Ribbon for Electronic Devices (B 180 - 43 T).

Test for Effect of Controlled Atmospheres Upon Alloys in Electric Furnaces (B 181 - 43 T).

Life Test of Electrical Contact Materials (B 182 - 43 T).

Light Metals

(Committee B-7)

Specifications:

Aluminum Sheet and Plate for Use in Welded Pressure Vessels (B 178 - 43 T).

Electrodeposited Coatings

(Committee B-8)

Recommended Practice:

Preparation of Low-Carbon Steel for Electroplating (B 183 - 43 T).

Filler Metal

(Joint Committee on Filler Metal)

Specifications:

Aluminum and Aluminum-Alloy Metal Arc-Welding Electrodes (B 184 - 43 T).

Chemical Analysis of Metals

(Committee E-3)

Specifications:

Apparatus and Reagents for Chemical Analysis of Metals (E 50 - 43 T).

Cement

(Committee C-1)

Method:

*Test for Compressive Strength of Portland-Cement Mortars (C 109 - 43 T).

Pigments and Paint Materials

(Committee D-1)

Methods:

Test for Dry to No-Pick-Up Time of Traffic Paint (D 711 - 43 T).

Test for Light Sensitivity of Traffic Paint (D 712 - 43 T).

Conducting Road Service Tests on Traffic Paint (D 713 - 43 T).

Evaluating the Degree of Blistering of Organic Coatings on Metal when Subjected to Immersion or Other Tests Involving Exposure to Moisture or Liquids (D 714 - 43 T).

Chemical Analysis of Barium Sulfate Pigments (D 715 - 43 T).

Chemical Analysis of Mica Pigment (D 716 - 43 T).

Chemical Analysis of Magnesium Pigment (D 717 - 43 T).

Chemical Analysis of Aluminum Pigment (D 718 - 43 T).

Chemical Analysis of Diatomaceous Silica Pigment (D 719 - 43 T).

Petroleum Products

(Committee D-2)

Methods:

*Test for Knock Characteristics of Motor Fuels (D 357 - 43 T).

*Test for Ignition Quality of Diesel Fuels (D 613 - 43 T).

*Test for Knock Characteristics of Aviation Fuels (D 614 - 43 T).

Test for Oil Content of Paraffin Wax (D 721 - 43 T).

Coal and Coke

(Committee D-5)

Methods:

Test for Free-Swelling Index of Coal (D 720 - 43 T).

*Sampling Coals Classed According to Ash Content (D 492 - 43 T).

Paper

(Committee D-6)

Methods:

Turpentine Test for Grease Resistance of Paper (D 722 - 43 T).

Test for Degree of Staining of Paper by Alkali (D 723 - 43 T).

Test for Surface Wettability of Paper (Angle of Contact Method) (D 724 - 43 T).

Test for Wire and Felt Sides of Paper (D 725 - 43 T).

Test for Resistance of Paper to Passage of Air (D 726 - 43 T).

Test for "Kerosine Number" of Roofing and Flooring by the Vacuum Method (D 727 - 43 T).

Electrical Insulating Materials

(Committee D-9)

Specifications:

Orange Shellac (Pure Garnet and Pure Button Lac) (D 237 - 43 T), supplement to Standard D 237 - 41.

Low and Medium-Voltage Pin-Type Lime-Glass Insulators (D 730 - 43 T).

Rubber

(Committee D-11)

Specifications:

Insulated Wire and Cable: Polyvinyl Insulating Compound (D 734 - 43 T).

Rubber and Synthetic Rubber Compounds for Automotive and Aeronautical Applications (D 735 - 43 T).

Methods:

Testing Compressed Asbestos Sheet Packing (D 733 - 43 T).

Test for Low-Temperature Brittleness of Rubber and Rubber-Like Materials (D 736 - 43 T).

Soaps

(Committee D-12)

Method:

Test for Volatile Hydrocarbons in Sulfonated Oils (D 500 - 43 T), supplement to Standard D 500 - 41.

Textiles

(Committee D-13)

Methods:

*Identification of Fibers in Textiles (D 276 - 43 T) supplement to Standard D 276 - 41T.

Test for Commercial Weight of Rayon Staple (D 540 - 43 T), supplement to Standard D 540 - 42.

Air Permeability of Textile Fabrics (D 737 - 43 T).

Testing and Tolerances for Rope (D 738 - 43 T).

Testing and Tolerances for Spun, Twisted, or Braided Products Made from Flax, Hemp, Ramie, or Mixtures Thereof (D 739 - 43 T).

Definitions of Terms:

Relating to Textile Materials (D 123 - 43 T), supplement to Standard D 123 - 42.

Plastics

(Committee D-20)

Specifications:

Vinyl Chloride - Acetate Molding Compounds (D 728 - 43 T).

Vinylidene Chloride Molding Compounds (D 729 - 43 T).

Method:

Test for Measuring Relative Mobility of Thermosetting Molding Powder (D 731 - 43 T).

Tentative Standard Withdrawn.

At the Annual Meeting, the Society accepted the recommendation to withdraw the Tentative Specifications for Fire-Retardant Properties of Wood for Scaffolding and Shoring (C 132 - 40 T).

District Committee Personnel and Local Meeting Plans

THE PERSONNEL OF the ten A.S.T.M. District Committees organized in as many leading industrial centers is rotated so that the terms of approximately one-third of the committee personnel expire every year, and under this plan of staggering expiring terms the president of the Society makes annual appointments. Recorded below are the names of members who have been designated to serve on the committees as a result of expiration of terms in 1943. Each appointment is on a three-year basis. It should be noted that the Cleveland District Committee has expanded its personnel by several new members bringing the number serving approximately in line with the numbers in Philadelphia, Chicago, and the other groups. The total number of members varies from 12 to 25 depending upon the particular area and various other factors.

With the personnel is given, for convenience, a list of the District Committee officers whose terms will not expire until 1944, election of officers being held in the even-numbered years, same as with the A.S.T.M. standing technical committees. One change should be noted particularly, the designation of W. C. Hanna, California Portland Cement Co., as chairman of the Southern California District Committee succeeding John Disario, deceased, and appointment of the former secretary, E. O. Slater, Smith-Emery Co., who has been very active in the work as vice-chairman, with R. E. Paine, Aluminum Co. of America, Pacific Coast Division, as the new secretary.

In general, the function of these district committees is to promote the interest of the Society in their particular areas. Usually district groups plan to have one or more meetings during the year including a technical treat of interest to a reasonable cross-section of the membership. These get-togethers provide an opportunity for members in the area who have not met some of their associates to do so. As indicated in the 1943 annual report of the Executive Committee, several of the districts have held outstanding meetings during the past year and a number are being planned for the 1943-1944 season. A few notes on projected meetings follow. In each instance a detailed notice is sent several weeks in advance to all A.S.T.M. members and technical committee representatives in the respective districts. Also, all officers of district committees are kept advised of meetings in other areas. When possible the president of the Society and representatives of the Headquarters Staff are present.

Philadelphia:

The Philadelphia District Committee, under the chairmanship of F. G. Tatnall, The Baldwin Locomotive Works, plans several meetings during the year, one of the early ones scheduled in October, October 21 or 28, to have as its feature an address by Dr. F. F. Lucas, Bell Telephone Laboratories, Inc., on the subject "Latest Microscopic Studies in the Fields of Biology and Rubber, Including New Color Techniques." The presiding officer at this meeting will be J. R. Townsend, Materials Standards Engineer, Bell Telephone Laboratories, Inc., new A.S.T.M. Vice-President. A number of medical people and others concerned with the subject involved will be in-

vited to participate. This is one of the educational type of meetings sponsored by the Philadelphia group. It will be held at the Franklin Institute on the Parkway.

Detroit:

The Detroit District Committee has for years followed the policy of arranging annually one outstanding technical meeting and in prospect is a symposium or topical discussion on "Stress Corrosion Problems" which would involve an introductory paper paving the way for two detailed discussions one of which would cover the galvanic and electrolytic reactions not only of metal to metal, but of corrosion medias to metal, which, depending upon material and temperature, may reverse themselves. In prospect for this discussion would be an informative paper on temporary protection of war materials in transit and for storage, on which a great deal of progress has been made in spite of the very involved problems. C. H. Fellows, The Detroit Edison Co., chairman of the district has appointed a committee with Messrs. E. W. Upham, *Chairman*, Chrysler Corp., C. E. Heussner, Chrysler Corp. and V. M. Darsey, Parker Rust-Proof Co., and they are making arrangements. Tentative plans call for an evening session in the fall.

Buffalo:

The most recently organized district—the Western New York—Ontario District Committee—centering in Buffalo, Rochester, and Toronto, will proceed on the basis of at least three meetings, one in each of the principal cities. The committee plans shortly to get into action again after its rather strenuous activities in connection with the very successful spring meetings of the Society held in Buffalo in March with the two technical symposiums now nearing publication on powder metallurgy and on paints, in particular, civilian defense and blackout coatings. B. L. McCarthy, Wickwire Spencer Steel Co., chairman of the district committee, with offices in Buffalo, and the two vice-chairmen, O. W. Ellis, Ontario Research Foundation, Toronto, and I. C. Matthews Eastman Kodak Co., Rochester, are arranging to dovetail all plans.

Several of the other districts will plan meetings and other features in connection with A.S.T.M. work and it is expected that get-togethers either formal or informal will be held in Chicago, New York, Cleveland, and other centers.

Chicago

Officers: E. R. Young, Chairman, Climax Molybdenum Co.; J. de N. Macomb, Vice-Chairman, Inland Steel Co.; C. E. Ambelang, Secretary, Public Service Co. of Northern Illinois.

Appointments: C. E. Ambelang, Public Service Co. of Northern Ill.; J. F. Calef, Automatic Electric Co.; J. de Macomb, Inland Steel Co.; W. A. Straw, Western Electric Co., Inc.; Paul Van Cleef, Van Cleef Brothers; E. R. Young, Climax Molybdenum Co.

Cleveland

Officers: A. J. Tuscany, Chairman, Metal Lath Manufacturers Assn.; Arthur W. Carpenter, Vice-Chairman, The B. F. Goodrich Co.; R. T. Bayless, Secretary, American Society for Metals.

Appointments: F. G. Steinebach, *The Foundry*, Penton Publishing Co.; R. B. Textor, The Textor Laboratories; A. J. Tuscany, Metal Lath Manufacturers Assn.; H. D. Churchill, * Case School of Applied Science; R. M. Conner, * American Gas Assn.; L. M. Currie, * National Carbon Co.; J. V. Emmons, * The Cleveland Twist Drill Co.; K. H. Osborn, * The Osborn Engineering Co.; C. E. Swartz, * Cleveland Graphite Bronze Co.

Detroit

Officers: C. H. Fellows, Chairman, The Detroit Edison Co.; Martin

Castricum, Vice-Chairman, United States Rubber Co.; W. P. Putnam, Secretary, The Detroit Testing Laboratory.

Appointments: T. A. Boyd, General Motors Corp.; V. M. Darsey, Parker Rust-Proof Co.; J. W. Kennedy, Huron Portland Cement Co.; J. L. McCloud, Ford Motor Co.; W. P. Putnam, The Detroit Testing Laboratory.

New York

Officers: M. P. Davis, Chairman, Otis Elevator Co.; E. A. Snyder, Vice-Chairman, Socony-Vacuum Oil Co., Inc.; G. O. Hiers, Secretary, National Lead Co.

Appointments: R. B. Barnes, American Cyanamid Co.; W. H. Bassett, Jr., Anaconda Wire and Cable Co.; J. G. Detweiler, The Texas Company; E. A. Snyder, Socony-Vacuum Oil Co., Inc.; W. L. Sturtevant, The Manhattan Rubber Mfg. Div. of Raybestos-Manhattan, Inc.; T. S. Taylor, Federal Telephone and Radio Corp.; Gordon Thompson, Electrical Testing Laboratories; R. M. Wilhelm, C. J. Tagliabue Mfg. Co.

Northern California

Officers: Dozier Finley, Chairman, The Paraffine Cos., Inc.; M. C. Poulsen, Vice-Chairman, Port Costa Brick Works; Theo. P. Dresser, Jr., Secretary, Abbot A. Hanks, Inc.

Appointments: R. E. Davis, University of California; T. P. Dresser, Jr., Abbott A. Hanks, Inc.; A. G. Jones, General Electric Co.; Dennistoun Wood, Southern Pacific Co.; F. E. Baxter* (alternate for F. M. Harris), Pacific Gas and Electric Co.

Philadelphia

Officers: F. G. Tatnall, Chairman, Baldwin-Southwark Division, The Baldwin Locomotive Works; L. E. Ekholm, Vice-Chairman, Alan Wood Steel Co.; R. W. Orr, Secretary, RCA Manufacturing Co., Inc.

* Indicates new appointment.

Appointments: E. J. Albert, Thwing-Albert Instrument Co.; L. E. Ekholm, Alan Wood Steel Co.; Tinius Olsen 2d, Tinius Olsen Testing Machine Co.; J. F. Vogdes, Jr., Philadelphia Committee of the Pennsylvania Economy League; L. D. Betz,* Firm W. H. & L. D. Betz; W. J. Jeffries,* Philadelphia Ordnance District, U. S. Army; Henry Sang,* Naval Aircraft Factory.

Pittsburgh

Officers: A. R. Ellis, Chairman, Pittsburgh Testing Laboratory; J. J. Shuman, Vice-Chairman, Jones and Laughlin Steel Corp.; H. A. Ambrose, Secretary, Gulf Research and Development Co.

Appointments: H. A. Ambrose, Gulf Research and Development Co.; A. R. Ellis, Pittsburgh Testing Laboratory; J. S. Gregorius, Pittsburgh Plate Glass Co.; J. O. Leech, Carnegie-Illinois Steel Corp.; S. M. Phelps, Mellon Institute of Industrial Research; F. N. Speller, Metallurgical Consultant; J. C. Sprague, Dravo Corp.

St. Louis

Officers: Hermann von Schrenk, Chairman, Consulting Timber Engineer; E. J. Russell, Vice-Chairman, Mauran, Russell, Crowell & Mullgardt; L. A. Wagner, Secretary, Missouri Portland Cement Co.

Appointments: A. A. Bareuther, St. Louis Ordnance Dist., U. S. Army; L. C. Hewitt, Laclede-Christy Clay Products Co.; L. A. Wagner, Missouri Portland Cement Co.; F. G. White, Granite City Steel Co.

Southern California

Officers: W. C. Hanna, Chairman, California Portland Cement Co.; E. O. Slater, Secretary, Smith-Emery Company; Roy E. Paine, Aluminum Co. of America.

Appointments: T. A. Fitch, Los Angeles Bureau of Standards; R. G. Osborne, Raymond G. Osborne Testing Laboratories; W. H. Jewell,* Pacific Clay Products.

Extensive 1943-1944 Publication Schedule

Includes Standards Supplements, Special Compilations of Standards, Technical Volumes

DURING THE NEXT few months, work will be concentrated on issuing a number of publications. These include not only the so-called regular publications—1943 Supplement to the Book of Standards, *Proceedings*, Year Book, INDEX TO STANDARDS—but also a number of special publications, including several compilations of standards which are of so much service in specific industries, and numerous technical volumes including certain symposiums. The number of pages involved is not nearly so heavy as the corresponding period a year ago when the more than 5000-page Book of Standards was under way, but it is nevertheless a very extensive schedule.

In September there will be sent to each member a Special Members' Order Blank listing various publications that will be available. Brief descriptions of the books will be given, together with an estimated date of appearance, and information on the members' special prices. As advance information, there are given below notes on the regular and several special books that are included in the schedule.

Regular Publications

1943 Supplement to Book of Standards

The three-year plan of publishing the Book of Standards provides that in the two years between publication of the complete book there will be issued Supplements. A Supplement to each part of the book therefore will be published late in 1943 and in 1944. The 1943 Supplement to each part of the book will include all of the proposed new standards accepted at the annual meeting and by Committee E-10 on Standards, all revised standards, and also all tentative specifications and tests which have been advanced from the status of tentative to standard.

The publication schedule provides for the distribution of the three 1943 Supplements in November, and each member will receive the parts corresponding to the respective Book of Standards Part which he ordinarily receives. Close to 50 per cent of the members get all three parts; the others get one or a combination of two parts.

Each of these Supplements will be completely indexed, bound in cloth—or on order in half-leather—and will include as a service a set of stickers for insertion in the 1942 Book of Standards.

1942 Proceedings

The *Proceedings* of the Annual Meeting will again be issued as one volume including both committee reports and technical papers, with discussion. Printing of the *Proceedings* is being scheduled for late in the year, with distribution sometime in January, 1944. Meanwhile, many of the papers are being reprinted in advance; some committee reports are also being issued as part of some one of the special compilations. Estimated pages in the *Proceedings*, about 1300.

1943 Index to Standards and Tentative Standards

This INDEX, which continues to increase in value as the number of specifications becomes larger, will again give the latest complete references to publications where the various specifications and test methods appear. The INDEX is furnished to members and is also widely distributed on request. Publication of the new edition is scheduled for late in December. This will probably aggregate 230 pages.

1943 Year Book

Includes a list of the complete membership of the Society (name, classification, address, company, etc.), the personnel of

all A.S.T.M. committees, and other pertinent information. Furnished only to members on request, for use in connection with activities of the Society. Publication date of this 360-page book—about September 25.

1943 Volume on Chemical Analysis of Metals

As indicated elsewhere in this BULLETIN, this publication is a very extensive revision of the former volume and will include all of the Society's standards and recommended practices relating to chemical analysis of both ferrous and non-ferrous metals and alloys, including procedures for spectrochemical analysis. The material is expected to be off press about August 25 with distribution in September. Previously members have been given an opportunity to request a cloth-bound copy of the book and to order extra copies. This book in one sense can be considered a fourth part of the Book of Standards, since the analytical methods for metals are not given in any of the three parts of the 1942 Book of Standards.

Special Publications

Symposiums on Powder Metallurgy and Paints

The two technical symposiums featuring the 1943 Spring Meeting in Buffalo are to be issued in the form of special volumes. The Powder Metallurgy Symposium will include the seven technical papers presented by outstanding authorities, plus discussion. Some of the topics covered include general discussion of powders, effect of pressure, the role of diffusion, particle size, alloy powders, and hot pressing.

The Symposium on Paint will include the papers on raw materials which include items on surface coating of paint pigments, calcium carbonated extenders, and water emulsion paints. The second section of this publication will include discussion on civilian defense coatings, concealment paints, camouflage materials, glass coatings, etc. Publication dates: Powder Metallurgy about September 15; Paints about October 15.

Manual on Refractory Materials

This interesting volume originally scheduled for publication in December, 1942, was postponed because of the desire of Committee C-8 on Refractories to make the publication as complete as possible and to include certain additional actions. In addition to all of the A.S.T.M. standards on refractory materials, a number of which have been modified—and with newer ones providing more adequate requirements for various materials—this book will include the several industrial surveys describing extensive uses of materials, and other information including data on standard samples and the like. A detailed prospectus will be sent to the members probably in September. Publication Date: about September 1.

1943 Edgar Marburg Lecture

There was much interest in this year's Marburg Lecture on "Wood as an Engineering Material," by L. J. Markwardt and prior to its publication in the 1943 *Proceedings*, special reprints of the lecture are being issued. This will aggregate some 75 pages and will be available about September 20. It is published in special format. Members can order copies through the Special Order Blank to be sent in September.

Bibliography and Abstracts on Contact Materials

Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys is sponsoring a very extensive bibliography complete with abstracts on contact materials. They cover the available literature on the electric arc, electric discharges in gases, contact, resistance, transfer of material, heating effects in contacts, circuit breaker design and testing, and general information on contact materials.

The manuscript is now almost complete and it is expected it will be placed in the printer's hands in the next few weeks, looking toward the appearance of the bibliography sometime in September. There are close to 1000 items and the bibliography and abstracts will comprise some 160 printed pages.

Compilation of Soil Test Procedures

At the 1943 Annual Meeting of the Society a preliminary Symposium on Methods of Testing Soils was held, looking toward holding a more formal symposium at a later annual meeting. In this preliminary symposium attention was called to a number of test procedures that are now in use. It is proposed to publish these as information in a compilation of soil test procedures including both adopted A.S.T.M. methods and those that have been submitted for consideration. This compilation will then serve as a preprint for the formal symposium to be held at a later date. It is expected that this compilation will be issued late in 1943.

Special Compilations of Standards

The widespread distribution of the special compilations of standards as sponsored by specific A.S.T.M. technical committees has been one of the interesting publication developments in the past few years. Several of the volumes include not only all of the A.S.T.M. specifications and tests pertaining to a specific field, but considerable supplementary information in the form of technical papers or reports, tables of data, and related information.

Some of the committees sponsor their books on an annual basis; others are issued biennially. Those which are expected to be developed in 1943 or very early in 1944 include the following:

Compilation	Publication Date
Steel Piping Standards (A-1)	September
Electrical Heating and Resistance Alloys (B-4)	October
Copper and Copper Alloys (B-5)	December
Cement (C-1)	September
Refractories (C-8), referred to above	September
Mineral Aggregates (C-9—D-4)	December
Petroleum Products and Lubricants (D-2)	September
Paper (D-6)	November
Electrical Insulating Materials (D-9)	December
Rubber Products (D-11)	December
Textile Materials (D-13)	September

Research is an organized method for keeping you reasonably dissatisfied with what you have.

Research is an organized method of finding out what you are going to do when you can't keep on doing what you are doing now.

Thinking is the one thing in the world upon which no one has ever been able to put a tax or tariff.

Just the minute you get satisfied with what you've got, the concrete has begun to set in your head.

—C. F. KETTERING

"I think right now we have need for the greatest soul-setting endeavor on record. In other words, we have got to set our course—not a random course, not a wishful course, but a course that will get us to the destination we want, whether it is a pleasant course or whether it isn't. I think with American ingenuity, with American faith, and with American determination, we can take this mysterious future which isn't so very clear and from it carve out anything that human imagination can think of that is worth carving out—that is, if it is for the benefit of the human family."

Concluding remarks by C. F. Kettering in an address, "Looking Forward Through the Eyes of Research," at Purdue University. Copies of complete address can be obtained from the Department of Public Relations, General Motors, Detroit, Mich.

Looking Ahead on Standardization Projects

Committees Have Numerous Specifications and Tests under Development—Several Actions Imminent

SUBSEQUENT TO the Annual Meeting, most of the Society's standing technical committees submitted statements or short programs of work outlining standardization projects which are under way or contemplated, and covering the status of research projects. Also, there is considerable information on standards work contemplated for the ensuing year in the committee reports as submitted at the Annual Meeting, practically all of which were preprinted and distributed to members. Much of this information is of interest to wide sectors of the membership, and the August BULLETIN yearly carries, as a service to members, a condensed review of this material.

Standards Published as Information and for Comments.—The list of specifications and test methods published in the 1943 reports on the recommendations of the various technical committees as information and for comment is quite extensive. This is standards work well advanced since many of the items will undoubtedly be approved as A.S.T.M. standards. In other cases where there is more than one proposal on a particular subject, a consolidation or selection may be needed.

The information which follows is recorded in the order of standing committee designations, that is, the "A" group, followed by the "B" group, non-ferrous, then the "C" and "D" groups in order.

Ferrous Metals

Steel.—The development of a test method or procedure for inspecting heavy forgings by magnetic powder or particle methods is an active project of Committee A-1 on Steel, where a special section has held one meeting with a "raft" being prepared following an outline approved at the meeting. This is just one phase of the use of magnetic powder testing, and other similar nondestructive test methods. In the field of castings, for example, there is considerable interest, and the application of magnaglo and zyglol processes is of interest in the non-ferrous metals field also. Other new projects in Committee A-1 included specifications for forged drums, which would be an amplification of the present boiler code specifications S-4, also two proposed emergency specifications covering blooms, billets, and slabs for forgings.

A joint project of Committees A-1 and A-10 on Iron, Chromium, Nickel and Related Alloys involves specifications for stainless pressure tubing. Based on the Pittsburgh meeting of the joint subcommittee responsible, specifications issued by the American Iron and Steel Institute are being rewritten in A.S.T.M. style and are being circulated to the pipe and tubular subcommittees of A-1 and A-10, and to additional consumers for comment. Once the basic specifications are issued the committee will then as the need arises consider covering specific applications.

A joint subgroup of Committee A-1 is studying the application of deoxidized acid bessemer pipe; another

project is to cover very small electric-resistance-welded pipe in the existing pipe specifications A53.

Corrosion of Iron and Steel.—While there is some delay because of concentration of members on war work, Committee A-5 on Corrosion of Iron and Steel will draft new specifications on chain-link fence galvanized before weaving and also on terne-plate specifications.

Magnetic Properties.—Further study of symbols of definitions so important in the field of magnetic properties will be made by Committee A-6, and this group has in mind taking a lead in coordinating different definitions and also making the A.S.T.M. sponsored nomenclature as simple as feasible.

Iron-Chromium, Iron-Chromium-Nickel and Related Alloys.—In Committee A-10, work is being started on methods of corrosion testing by complete immersion, which would be along the lines of the new test issued by Committee B-3, but more directly applicable to stainless steels. A new purchase standard to cover hot-rolled stainless bar steels is under way to cover some ten grades of chromium and chromium-nickel alloys.

An important project, the first phase of which is practically completed, includes three specifications for so-called clad material. These specifications cover chromium, chromium-nickel, and nickel clad plates. In the field of castings, the first draft is under way for a standard to cover materials for heat resistance service primarily for applications in the refinery industry.

General Metals

Metallography.—A recommended practice for analysis of preferred orientations in metals is being approved in the committee and will be submitted to the Society for action.

Non-Ferrous Metals and Alloys

Copper Wires for Electrical Conductors.—One project on which Committee B-1 on Copper and Copper-Alloy Wires for Electrical Conductors is concentrating for the year is the development and promulgation of a method of test for resistivity of copper conductors, with particular reference to conductors in shapes other than what are termed wire, including tubes, bars, angles, channels, etc.

Electrical-Heating, Electrical-Resistance, and Electric-Furnace Alloys.—Intensive work has been under way and will continue in two important fields in the jurisdiction of Committee B-4, one on metallic materials for radio tubes and incandescent lamps and the other on contact metals. An investigation of testing and grading of powders used in radio tube production is being carried on, and also under study are methods of test for tungsten wire for glass seals. In the work on contact materials the committee has been developing recommendations of size of solid rivets and also pointed head rivets. Data are being compiled on

standardization of sizes of projection welding contacts also.

Reference is made in this BULLETIN to the pending publication of a very valuable bibliography and abstract of some 700 references to articles on contact materials.

Electrodeposited Coatings.—In order to clarify whether thin copper undercoatings are desirable with lead plating on steel, Committee B-8 on Electrodeposited Coatings plans to conduct some experimental tests prior to preparation of specification requirements. Another project will be a study of standard specifications for silver coatings on steel. An investigation of suitable procedures for detecting porosity in electrodeposited coatings is being planned and the drafting of a recommended practice for a preparation of high-carbon steel for electroplating has been assigned as a definite project for the year.

"C" Committee Group—Cement, Concrete, etc.

Cement.—Committee C-1 on Cement announced that a method of determining Vinsol resin in portland cement has been drafted based on cooperative tests, and distribution has been made to the committee for study. Also nearing completion in draft form for reference to the committee is the text of a proposed method of determining heat of hydration of portland cement, which employs a simple thermos jar calorimeter the same as in Federal Spec. SS-C-158a. Of interest in this connection was the Annual Meeting paper by Messrs. Shartsis and Newman involving the heat of solution procedure for determining the heat of hydration of portland cement.

Fire Tests of Materials and Construction.—Committee C-5 in charge of work in this field will reconsider the proposed methods of testing window assemblies published in its report but not accepted at the annual meeting, and the group will also assist in accumulating further test data on procedures for fire tests on acoustical and similar finishes. The tunnel type test is designed to give data on flame spread, fuel contributed, and the amount of smoke generated.

Concrete and Concrete Aggregates.—Several projects are before the subcommittee on methods and apparatus for testing concrete, one of the groups in Committee C-9, including standards for the following: determining water gain; making concrete test specimens from vibrated concrete; rate of loading of concrete test specimens; tests for uniformity of concrete proportions; making concrete beams in the field; methods of capping compression specimens; and freezing-and-thawing tests of concrete. In work on specifications and tests for aggregates, a revised procedure for retaining surface moisture of fine aggregates is being drafted.

Thermal Insulating Materials.—Committee C-16, which had done such a commendable piece of work in drafting numerous emergency specifications for various types of thermal insulating materials and products (ES 8 through ES 19), plans to undertake standardization of methods for determining specific heat, coefficient of linear expansion, and other thermal properties of heat insulation materials. Also, since there seems to be urgent need for standard tests covering vapor barriers in air conditioning and refrigeration fields, a new subcommittee just organized will proceed actively.

"D" Committee Group—Paints, Petroleum, Coal, Textiles, Plastics, etc.

Paints, Varnishes, Lacquers, etc.—The work of Committee D-1 has been influenced by scarcity of certain materials, evident from the fact that with many oils coming into use for paint and varnish, specification requirements for them are necessary, and also new methods of evaluating their properties must be studied. The committee will continue its efforts to meet the urgent needs for reliable methods of determining quickly the durability in service of paint, varnish, and other organic coatings. The committee has recently devised photographic standard scales for the quantitative expression of the degree of failure of coatings by exposure due to chalking, cracking, and other defects. These scales will be extended to cover still other forms of failure.

In the field of chemical analysis, methods are to be developed for flat drying paints which are now largely used. Similar investigations are projected for certain synthetic resin finishes.

As a means of judging the character and quality of organic coatings, physical tests are coming more and more to the fore. The committee has under way extensive investigations on drying time, preparation of special test panels, gloss of the dried films, flame testing, the effect of infrared light, and the numerical expression of color. This last item is especially important from the standpoint of absolute and precise description of the color of a paint and of preparing finishes which will fully match others under all conditions of illumination and vision.

The committee will shortly complete an investigation of methods of preparing steel surfaces for painting, including the use of preliminary treatments to inhibit corrosion of the metal and to increase the adherence of the paint. Such processes aid in the conservation of steel and the permanence of structures.

Gaseous Fuels.—Activities in this field in the charge of Committee D-3 have involved considerable research, subsequent to which test methods are being pressed. In the work on calorific value a method for determining the heating value of gases with a flow type calorimeter has been substantially agreed on, and it is hoped this can be offered to the Society for publication during the year.

Road and Paving Materials.—In the work of Committee D-4 on preformed expansion joint filler, revisions are anticipated in the two specifications D 544 and D 545 covering inclusion of the bituminous fiber type of joint. Changes are also pending in the specification requirements for tar, to bring them in line with current practice, and another item on which there has been considerable interest involves a test for extraction and recovery of bitumen from bituminous mixtures. It is hoped a proposed tentative method can be referred to the Society during the summer for approval.

Coal and Coke.—A proposed combination of the present Standard Method of Sampling Coal for Analysis, D 21, and the current Tentative Method of Sampling of Coal Classed According to Ash Content, D 492, is a project before Committee D-5. Also under development is a method for sampling coals for volatile matter determination in connection with city smoke regulations. Another problem involves study of several methods for determination of plastic properties, volume changes, and pressures de-

veloped during carbonization of coal in the manufacture of coke, as proposed in the 1943 preprinted report so that the ones that are best suited can be selected and be submitted as A.S.T.M. tentative standards.

In the work on ignitibility, a proposed test which was covered in a 1941 A.S.T.M. annual meeting paper will be studied. The committee plans to revise the present Standard Method for Designating the Size of Coal from Its Screen Analysis, D 431. The revision is intended to make the method conform to current usage of the majority of coal trade associations and that of various governmental agencies.

Electrical Insulating Materials.—Through its numerous subcommittees and sections, Committee D-9 has a large number of projects under way involving both research and standardization, including the following: development of flexure test methods for plates, tubes, and rods, and also requirements on conditioning prior to mechanical testing. Standardized test for Askarels and water in insulating oils are being developed. In the field of ceramic products a test covering properties of high dielectric constant insulating materials is under study, and the work on insulating fabrics will cover dielectric strength and fatigue characteristics of varnished cambric, as well as the same characteristics of varnished cambric and varnished glass tapes. Studies will continue on specification requirements for mica for condensers and other uses. The active development of apparatus for tests of plastic materials at both high and low temperatures continues.

Rubber and Rubber-Like Materials.—The work of Technical Committee A on Automotive Rubber, this committee being under the joint auspices of A.S.T.M. and S.A.E., continues with the drafting of two purchase specifications covering coolant system hose for use in combat tank applications where the service is severe and the hose must withstand pressure, various types of coolant liquids, both hot and cold temperatures, and unskilled application to fittings. The other specification is for an all-reclaim non-combat vehicle radiator hose which is only suitable for less severe service and which should not be used except when fully approved by both producer and consumer.

The drafting of sponge rubber and sponge-rubber products specifications continues, involving chemically blown sponge rubber, foamed latex sponge rubber, and closed cell type of sponge rubber. Proposed standards are being circulated among interested parties.

The subcommittee on rubber-coated fabrics has prepared a preliminary draft covering a group of test methods which will form the nucleus of a tentative standard on fabrics coated with rubber or rubber-like materials. It is hoped to have this ready for presentation to Committee D-11 and to the Society in the very near future.

Soaps and Other Detergents.—Quite a number of standardization projects are being developed in Committee D-12, including specifications requirements for liquid soaps, methods of evaluating sulfonated detergents and metal cleaners, and test for dry cleaning detergents. Also to be studied are methods for water insoluble in paste and liquids soaps, and further methods for soap analysis.

Textile Materials.—Committee D-13, which as H. J. Ball indicates in his A.S.T.M. presidential address (see Annual Meeting article in this BULLETIN) has covered a very extensive territory, has its work divided into subcom-

mittees covering cotton, rayon, wool, etc. The work on rayon tire fabrics will include studies on thickness measurements on tire cords; rayon cord fatigue testing; method of calibration of pendulum type testers for elongation; and a method for the determination of yards per pound of tire cord. Specifications for numbered ducks, heavy woven cotton fabric, are in course of development. The work on wool includes standards for wools below grade 50's and also new test methods. Another standardization project is the development of a method for determining moisture of textiles on oven drying. The work on pile floor covering includes methods for determining the susceptibility of pile floor coverings to matting.

Naval Stores.—Committee D-17 on Naval Stores will continue investigation of methods for determining softening point to develop a suitable method for rapid control work; also an acceptable test method for determining crystallizing tendency in rosin. Other tests to be drafted will cover determination of excessive residual turpentine or other volatile oils in rosin, and other saponifiable matter in rosin. In the field of liquid rosin (Tall Oil) standard definitions and grades will have consideration.

Water for Industrial Uses.—In its work on methods of sampling, Committee D-19 has been studying various suggestions submitted by members dealing with sampling of boiler feed water, boiler water, and steam. From these standards it is hoped to develop standard methods covering both control and referee procedures.

Plastics.—Committee D-20 on Plastics which during the past year carried out a most intensive standardization program continues its active work. New tentative tests are virtually completed covering determination of tensile, compressive, and impact strengths at subnormal and supernormal temperatures; also a proposed tentative standard for tensile strength of thin plastic sheets. In this same field proposed standards have been drafted covering tests for brittleness and stiffness in flexure of non-rigid plastics. The committee plans to develop standard molds for various test specimens required. Also under study are standardized procedures to cover bearing strength and impact strength at high speed or under load.

In the work on thermal properties there has been completed a standardized test method for determining flammability of sheet and plate material by the Glo-bar method. Also included in this subcommittee work are methods of test for cubical expansion, and a simplified procedure for determining heat distortion. In the field of optical properties the committee will investigate work relative to optical clarity, transmission and reflectance, and associated characteristics of plastics. Other tests in the committee, involving permanence properties will include a method for resistance of plastic or plastic parts to extreme service conditions, and tests for accelerated weathering, permanent and semi-permanent effect of heat. Consideration of the test for resistance to severe service conditions, will be given at a conference to be called shortly.

The work on specifications so notable during 1942-1943 will be further advanced through proposed new specifications covering (1) Non-Rigid Polyvinyl Butyral, (2) Polyvinyl Chloride-Acetate, (3) Polyvinyl Chloride, (4) Ethyl Cellulose Plastics, and (5) Ethyl Cellulose Molding

Compositions. Revisions in three existing specifications approved in recent months are contemplated—one on Polystyrene Molding Compounds (D 703 - 43 T) to include a third type of material. The others, D 706 - 43 T on cellulose acetate and D 707 - 43 T on cellulose acetate butyrate, will include corrections in the dielectric strength determination. The committee reported considerable progress in developing analytical standards for methanol soluble content and viscosity of polystyrene and on a method of determining acetyl and butyryl content of cellulose acetate butyrate. It is actively engaged in tests on nitrocellulose, methacrylates, and chlorine containing resins. Also under consideration are methods for determination of plasticizer content and specific gravity.

Cross-Index of Chemically Equivalent Metals Specifications and Identification Code Available

RECENTLY ISSUED through the activities of General Motors Corp. in cooperation with other companies and certain national technical and trade organizations is a Cross-Index of Chemically Equivalent Metals Specifications and Identification Code. This material was initiated at the suggestion of the U. S. Armed Services, and is issued primarily as an aid in translating bills of materials and specifications into terms of basic industrial and raw material requirements. The code numbers are not intended nor can they be used as a specification or for procurement purposes. They are useful in making bills of materials reports. This is particularly true in machine compilation of bills where the use of actual specifications is difficult due to lack of space and machine limitations. This publication is in three parts: Part I presents the exact chemical analysis of the specifications. No attempt has been made to show physical properties required. Part II lists the specifications of each of the various organizations in order, and the code number identifying the group to which each specification number is indexed. Part III is a numerical listing of the code numbers and their nominal compositions.

Copies of this extensive Index in heavy paper cover can be obtained without charge from the Office of the Vice-President in Charge of Engineering, Attention R. L. McWilliams, Room 8-133A, General Motors Building, Detroit, Mich. A.S.T.M. members who request the code should indicate their Society connection.

New Committee Officers

THREE A.S.T.M. STANDING committees have new officers, as follows:

Committee A-1 on Steel:

New Producer Vice-Chairman: J. O. Leech, Carnegie-Illinois Steel Corp.

Committee D-7 on Timber:

New Secretary: L. J. Markwardt, U. S. Forest Products Laboratory, succeeding J. A. Newlin, deceased.

Committee E-7 on Radiographic Testing:

New Secretary: Don M. McCutcheon, Ford Motor Co., succeeding R. A. Gezelius, General Steel Castings Co.

A.S.A. War Work

THE LIST of standards which have been approved under the procedures of the American Standards Association includes a number of so-called American War Standards which have been promulgated in accordance with a procedure formally approved by the member bodies and directors of the Association. This procedure has included the appointment of certain A.S.A. War Committees which have carried out development work and whose recommendations are referred to an appropriate A.S.A. correlating committee or its Board of Examination. Final approval is vested in the chairman of the A.S.A. Standards Council.

A list of the American War Standards follows:

A85-1942	Protective Lighting for Industrial Properties
B1.4-1942	Straight Screw Threads for High-Temperature Bolting
B5.16-1941	Accuracy of Engine Lathes
B16a1-1943	Pressure Ratings for Cast-Iron Pipe Flanges and Flanged Fittings, Class 125
B16c5-1943	Pressure-Temperature Ratings for Steel Pipe Flanges, Flanged Fittings, and Valves (Revision of Tables 6 to 11, inclusive, American Standard B16c-1939)
C12WS-1942	Code for Electricity Meters (Revision of Paragraph 827)
C16.6-1943	Fixed Paper-Dielectric Capacitors (Home Receiver Replacement Type)
C16.7-1943	Dry Electrolytic Capacitors (Home Receiver Replacement Type)
C16.8-1943	Simplified List of Home Radio Replacement Parts (Paper and Electrolytic Capacitors, Volume Controls, Power and Audio Transformers and Reactors)
C16.9-1943	Power and Audio Transformers and Reactors (Home Receiver Replacement Type)
C39.2-1943	Electrical Indicating Instruments (2 1/2- and 3 1/2-Inch Round, Flush-Mounting, Panel-Type)
C39.3-1943	Shock-Testing Mechanism for Electrical Indicating Instruments (2 1/2- and 3 1/2-Inch Round, Flush-Mounting, Panel-Type)
C74-1942	Machine Tool Electrical Standards
C75.1-1943	Ceramic Radio Insulating Materials, Class L
C75.3-1942	Fixed Mica-Dielectric Capacitors
C75.4-1943	Ceramic Radio Dielectric Materials, Class H
C75.5-1943	External Meter Resistors (Ferrule Terminal Styles)
Z1.1-1941	Guide for Quality Control
Z1.2-1941	Control Chart Method of Analyzing Data
Z1.3-1942	Control Chart Method of Controlling Quality During Production
Z21.1ES-1942	Domestic Gas Ranges, Approval Requirements for
Z21.10WS-1942	Gas Water Heaters, Approval Requirements for
Z37.5-1941	Allowable Concentration of Cadmium
Z37.6-1942	Allowable Concentration of Manganese
Z38.2.2-1942	Photographic Exposure Computer
Z41.1-1943	Men's Safety-Toe Shoes
Z41.2-1943	Women's Safety-Toe (Oxford) Shoes, 2nd ed.
Z41.3-1943	Men's Conductive Shoes, 2nd ed.
Z41.4-1943	Men's Explosives-Operations (Non-Sparking) Shoes
Z41.5-1943	Men's Electrical-Hazards Shoes, 2nd ed.
Z41.6-1943	Men's Foundry (Molders) Shoes, 2nd ed.
Z41.7-1943	Women's Safety-Toes (High) Shoes
Z41.8-1943	Women's Explosives-Operations (Non-Sparking) Shoes
Z41.9-1943	Women's Conductive Shoes
Z44-1942	Specification and Description of Color

A number of other war standards under way cover military radio equipment and parts.

Copies of the list of standards approved by the A.S.A. can be obtained from its headquarters, 29 West 39th St., New York, N. Y. The list gives prices of the standards and the designations applicable. In the case of standards which have been approved on recommendation of other societies, for example, the large number of A.S.T.M. standards, the society serial designations also are given.

Welding of Low Carbon Steel

A RECOMMENDED Practice for the Spot and Seam Welding of Low-Carbon Steel has just been issued by the American Welding Society as an emergency standard. The data which form the basis of the standard were compiled from a large number of fabricators of mild steel structures and resistance welding equipment manufacturers. The data are condensed in two tables—one on spot, the other on seam welding. For various metal gages, the minimum electrode diameters and shape are given with the pressure, weld time, approximate current, minimum weld strength, approximate diameter of fused zone, minimum overlap, and weld spacing. Copies of the four-page bulletin can be obtained from the A.W.S. offices, 33 W. 39th St., New York, N. Y., at 10 cents each.

Chart of War Metallurgy Committee

THE ACCOMPANYING chart showing the organization of the War Metallurgy Committee and its relation to certain other agencies will be of interest to many members. This chart is part of a new booklet describing the purposes, aims, and work of the committee, and listing the personnel of various advisory groups. It will be noted from the chart that a number of A.S.T.M. members are serving in an official capacity with the committee, and countless other members are cooperating. Research projects are handled for technical branches of the War Production Board and for the National Defense Re-

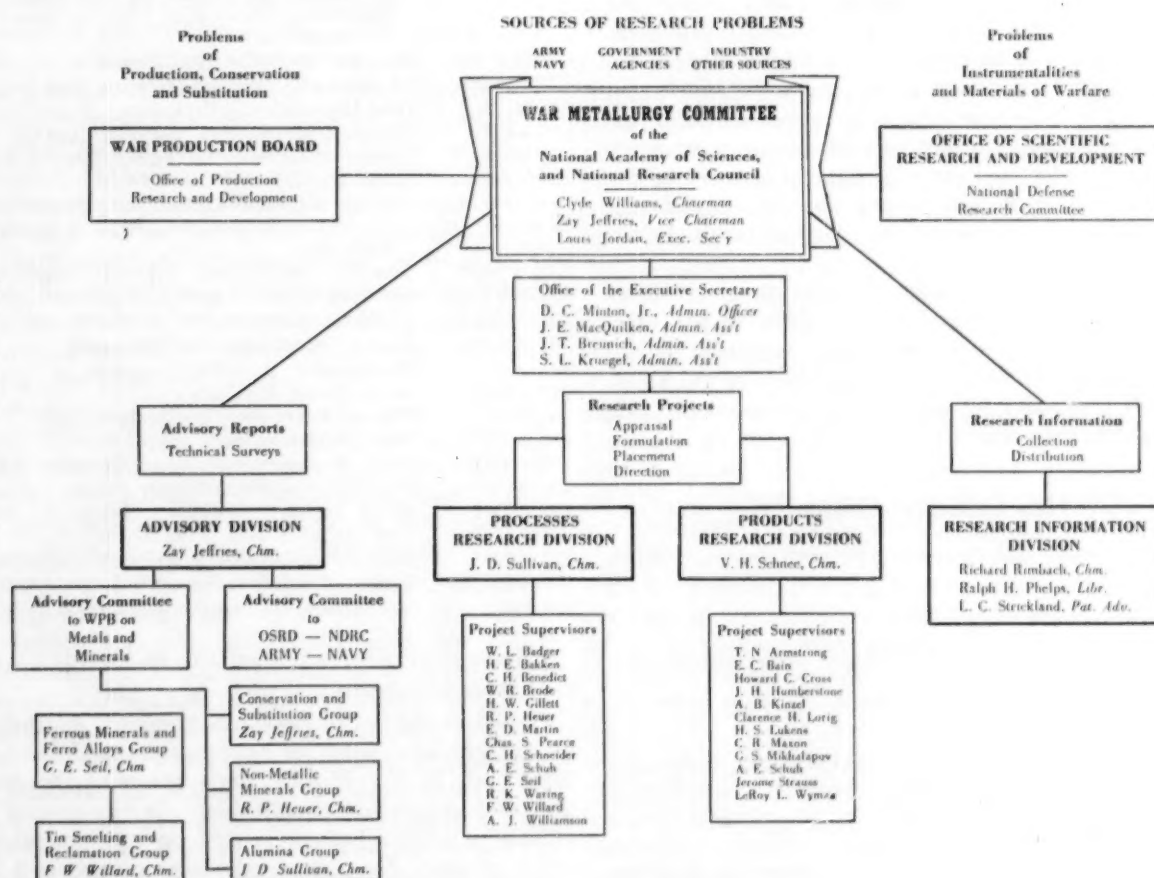
Emergency Federal Specifications

FROM THE VERY large list of Emergency Alternate Specifications received at A.S.T.M. Headquarters there has been selected many which it is believed would be of concern to a reasonable cross-section of the Society's membership and the titles of these are given below. Constantly these emergency specifications are being issued, some to supersede previously issued emergency documents—in all cases, of course, the object is to expedite procurement or to conserve strategic or critical materials.

E-HH-P-151a	Packing, Rubber; Cloth-Insertion
E-HH-T-101a	Tape; Friction
E-P-S-586	Soap; Laundry, Liquid
E-P-S-618a	Soap; Toilet, Liquid
E-T-R-601a	Rope; Manila
E-ZZ-B-426	Blankets; Rubber
E-ZZ-H-421a	Hose; Chemical
E-ZZ-H-461a	Hose; Gas (Acetylene, Air, Hydrogen, and Oxygen)
E-ZZ-H-471	Hose; Gasoline, Wire-Stiffened
E-ZZ-H-561b	Hose; Suction, Water, Smooth-Bore
E-ZZ-S-311a	Sheeting; Rubber
E-ZZ-T-831b	Tubing; Rubber
E-ZZ-V-51a	Valves; Rubber

search Committee of the Office of Scientific Research and Development.

Some 50 research laboratories are handling phases of the work, with several hundred scientists and technicians employed. A number of technical societies and special groups have rendered assistance to the War Metallurgy Committee, including A.S.T.M.



Material Substitution and Supply List No. 9

ISSUE No. 9, Material Substitution and Supply List, as released by the WPB Conservation Division on July 15 shows a number of important shifts in the relative position of materials, including a general tightening of an already critical lumber situation which places most hardwoods and most 1-in. boards of all species in Group I. The list groups some 500 materials essential to the war program in three categories reflecting relative availability: Group I, materials *Insufficient* for essential war and industry needs; Group II, materials approximately in *Balance* with requirements; and Group III, materials available for *Substitutes* in essential applications.

Several substitutes for lumber, demand for which has been increased by many factors, including requirements for overseas containers, are now listed in Group III. These include asphalt laminated board; asbestos cement sheets; granule surface insulation board; and structural surface board.

The new issue contains numerous changes in the group listings. Moved from Group I to Group II (indicative of an easing supply trend) were the following chemicals: Acrylic acid; aluminum chloride; ammonia and derivatives; chlorosulfonic acid; and sulfur chlorides. On the other hand, sulfuric acid and glycols have become more critical.

Among other products moved to Group I from Group II, reflecting greater demand, are: horse tail and mane cattle tail hair; alkyd resins; cadmium pigments; linseed oil; Ponderosa pine plywood; and silicon carbide abrasives.

A trend toward downgrading—the replacement of critical materials with generally satisfactory substitutes with slightly modified characteristics—is indicated in the introduction to the List by reference to the Conservation Division's "Downgrading Chart for Brass and Bronze" and "Aluminum Alloy Substitution Chart," both of which allow generous use of scrap materials. (Copies of these charts can be obtained from the Conservation Division.)

The following clue to the relative position of steel and wood in industrial applications was given in the introductory notes to the List: "The choice between steel and wood depends largely on type of need, application, and local conditions. However, no relative change has occurred in the wood supply situation which necessitates wholesale switches back to steel.

Increased production has resulted in an easier position in magnesium, while certain other critical non-ferrous metals and ferro-alloys are slightly easier, largely reflecting more direct channeling to essential needs. Among materials that have grown more critical since Issue No. 8 (April) are: hardwood species of lumber, columbium, sperm oil, phthalic anhydride and derivatives, vulcanized fiber, phenolic laminates, ethyl cellulose, sulfuric acid, vitamin A oils. New items in this issue include: ethyl acetate, anhydrous hydrofluoric acid, concentrated superphosphates, cellulose sponge, wool grease.

Copies of Material Substitutions and Supply List, Issue No. 9, may be obtained upon written request to the Conservation Division, War Production Board, Washington 1, D. C.

A Feeling of Satisfaction

EDITOR'S NOTE.—In recent BULLETINS brief notes have been included at the suggestion of the Executive Committee describing some of the assets of membership in A.S.T.M.—such items as "Preprints," "Proceedings," "Book of Standards," "The Value of Committee Participation in Technical Committee Work," and "Contacts with Members at Meetings." The following suggestion of a membership asset is of a different nature, namely, the satisfaction which each member of A.S.T.M., or representative of a company membership can have in the support of notable work.

MEMBERSHIP MAY be and frequently is held in various organizations by individuals or companies as a very practical or a rather prosaic matter, to obtain publications, to keep in touch with developments, frequently to maintain a competitive standing, and in some cases, many organization memberships are doubtless held simply to be able to report that they are members of this or that organization with very little benefit resulting. Since the work of any organization is in large part a reflection of the members' activities and participation, any member of a parent group which can note over long periods of time very tangible and helpful activity can take pride in his membership, for it is his individual or company support multiplied by a few hundred or a few thousand which makes the larger group function. True, he may take a more active part in the work by helping in committees, by preparing technical papers, or by serving in an executive capacity if so honored, but the rank and file member of an active technical society like A.S.T.M. may with pride point to his membership as such, and can rightly have satisfaction merely from being a member. True, very few members do take pause and pat themselves on the back for holding membership in A.S.T.M., but to do so would be pardonable. Constantly throughout the years the Executive Committee of A.S.T.M. and the Administrative Staff recognize that the Society has reached its present position because of such a consistently loyal group of members.

Laboratory Material

PRIORITY ASSISTANCE for materials required by scientific and technological laboratories and deliveries of laboratory equipment are affected by two amended orders (P-43 and L-144) issued on June 26 by the WPB.

Order P-43 as amended assigns preference ratings and an allotment symbol to laboratories, to assist them in obtaining all materials and equipment needed to carry on scientific or technological activities.

All laboratories receive a preference rating and allotment symbol under the amended order. However, those laboratories carrying on work of great importance to the war effort are entitled to obtain a serial number under the order; and if they obtain a serial number, they may use a higher preference rating than other laboratories. (Serial numbers assigned under the former Order P-43 are valid under the amended order without reapplication.) Also, all laboratories owned or operated by the Army or Navy receive high preference ratings.

Order L-144 restricts the delivery of any one item or quantity of the same item of laboratory equipment having a value of \$50 or more, or the delivery on a purchase order of laboratory equipment worth \$200 or more, even though no item or quantity of the same item on the order has a value of \$50 or more, unless authorized by WPB on Form WPB-1414 (formerly PD-620).

Purchase orders of the Army and Navy and laboratories with serial numbers under Order P-43 as amended are exempted from this restriction, except on purchase orders for certain highly critical equipment.

Previously, L-144 required a certification as to the use of laboratory equipment and imposed certain restrictions on the right to make certification. The present amended order eliminates this requirement.

New Handbook of Plastics

AN IMPORTANT new handbook of over 1100 pages by Herbert R. Simonds, Consulting Engineer, and Carleton Ellis, late President of Ellis Laboratories, Inc., with the assistance of Captain M. H. Bigelow, Chemical Warfare Service, U. S. Army, has just been issued by D. Van Nostrand Co., Inc., 250 Fourth Ave., New York, N. Y. Following the death of Mr. Ellis, Mr. Simonds carried on and enlisted a larger staff including workers from Ellis Laboratories and others. An Advisory Committee of sixteen technical and scientific leaders in the plastics field, many of whom are active in A.S.T.M. work, cooperated and there were many others. The book is designed to present in detail and yet with proper selection the fundamental basis and technology of the plastic industry. It is arranged in nine major sections—a list of these follows, which with the approximate number of pages involved will indicate the relative amount of material in each main topic.

Section	Pages
I Introduction	28
II Physical Properties of Plastics	196
III Materials	246
IV Manufacture of Plastics	78
V Processing and Fabrication	166
VI Chemistry of Plastics	72
VII Applications of Plastics	70
VIII Commercial Considerations	58
IX Appendix—Glossary—Bibliography	106

Every section of the book would be of definite interest to workers in the plastic field and others. The section of Physical Properties is of particular concern to many A.S.T.M. people. A chapter on test methods covers almost 100 pages and gives the main features of a large number of A.S.T.M. tests. (These tests are listed in the general index.) A rather unique part of the book is an extensive chapter giving condensed commercial catalogues of leading manufacturers of powders and synthetic resins.

The chapter on Practice includes discussion of physical tests, production control, and testing of finished products. Very interesting parts of the book include chapters on Estimating and Paper Work and another on Workers' Welfare.

The section of the book on Materials (over 200 pages) covers plastic materials as such, fibers, synthetic rubbers, resins, films, plywood, and synthetic coatings.

There are 130 tables, some of them extremely extensive, an outline, and a very detailed table of contents, book bibliography, name index, and general index of 60 pages. An appendix with a general and a chemical glossary, and a list of trade marks and trade names are helpful supplements to the text.

Copies of this new handbook can be obtained from the publisher at \$10 each.

Index to Emergency Federal Specifications

THE LATEST Index to Emergency Alternate Federal Specifications dated July 1 includes for the first time a list of the standards and amendments which contain provisions for the conservation of critical or strategic materials. This booklet lists all current and cancelled emergency alternate items issued from April 29, 1941 to June 15, 1943. For convenience, the specifications are listed the same as in the Standard Stock Catalogue, namely both alphabetically and by commodity groups. This index is the seventh in the series that has been developed and published by the WPB Conservation Division, and A.S.T.M. members who would find the index of particular service may obtain a copy without charge as long as the supply lasts, by contacting Harlan W. Bird, Materials Branch, WPB Conservation Division, Washington 1, D. C.

Society Appointments

Announcement is made of the following Society appointments:

A. J. KELLNER, United States Testing Co., Inc., on the Inter-Society Color Council, to succeed C. J. Huber, United States Testing Co., Inc., as a representative of Committee D-13 on Textile Materials.

E. P. PARTRIDGE, Hall Laboratories, Inc.; A. J. PHILLIPS, American Smelting and Refining Co.; and L. J. TROSTEL, General Refractories Co. Laboratories, as members of Committee E-1 on Methods of Testing for terms of three years.

J. R. FREEMAN, JR., American Brass Co.; C. E. HEUSSNER, Chrysler Corp.; and L. M. CURRIE, National Carbon Co., as members of Committee E-6 on Papers and Publications for terms of three years.

G. B. WATERHOUSE, Massachusetts Institute of Technology, and J. W. McBurney, National Bureau of Standards, as members of Committee E-8 on Nomenclature and Definitions for terms of three years.

O. E. HARDER, Battelle Memorial Institute, as a member of Committee E-9 on Research for a term of five years.

N. L. MOCHEL, Westinghouse Electric and Manufacturing Co., and L. B. JONES, The Pennsylvania Railroad Co., as members of Committee E-10 on Standards for terms of three years.

* New appointments; all others reappointed.

Directory of Commodities and Services

RECENTLY ISSUED by the Office of Price Administration is a Directory of Commodities and Services which is an index to price and rationing regulations and jurisdiction of operating units. Following an organization directory, a list of O.P.A. price and rationing regulations, and an alphabetical index of commodities and services, is a very detailed price branch index covering foods; fuel; industrial manufacturing division; industrial materials division; textiles, leather, and apparel division; services and consumer durable goods division; transportation and public utilities division.

Copies of this 292-page book in heavy paper cover can be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., at 30 cents each.

Calendar of Society Meetings

(Arranged in Chronological Order)

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—September 2-4, Salt Lake City, Mo.

NATIONAL SAFETY COUNCIL—October 5-7, Sherman, La Salle, and Morrison Hotels, Chicago, Ill.

OPTICAL SOCIETY OF AMERICA—October 7-9, Pittsburgh, Pa.

AMERICAN GAS ASSOCIATION—Twenty-fifth Annual Meeting, October 11-13, Jefferson Hotel, St. Louis, Mo.

AMERICAN WELDING SOCIETY—Annual Meeting, October 18-21, Hotel Morrison, Chicago, Ill.

AMERICAN SOCIETY FOR METALS—Annual Convention, October 18-22, Palmer House, Chicago, Ill.

AMERICAN PETROLEUM INSTITUTE—Twenty-fourth Annual Meeting, November 8-11, Palmer House, Chicago, Ill.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Annual Meeting, November 29-December 3, New York, N. Y.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE—December 27-January 1, Cleveland, Ohio.

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SOCIETY OF AUTOMOTIVE ENGINEERS—Annual Meeting and Engineering Display, January 10-14, Book-Cadillac Hotel, Detroit, Mich.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS—Annual Meeting, February 20-24, Waldorf-Astoria Hotel, New York, N. Y.

Emergency Specifications and Alternate Provisions

SINCE THE MAY issue of the ASTM BULLETIN in which was the latest information on emergency specifications and alternate provisions, several additional emergency actions have been approved as follows:

Emergency Specifications for Electrodeposited Coatings of Lead on Steel ES - 31

EA - A 158 Seamless Alloy-Steel Pipe for Service at Temperatures from 750 to 1100 F. (A 158 - 42 T)

EA - A 206 Seamless Carbon-Molybdenum Alloy-Steel Pipe for Service at Temperatures from 750 to 1000 F. (A 206 - 42 T)

EA - D 69a Friction Tape for General Use for Electrical Purposes (D 69 - 38)

Electrodeposited Coatings of Lead on Steel:

These emergency specifications developed by Committee B-8 on Electrodeposited Metallic Coatings provide for six types of coating and cover manufacture, thickness, continuity, test requirements, and related matters. Supplementary information is included in appendices with recommendations to the manufacturer so that he can meet the thickness specifications; there are recommendations on time required for plating and also alternate methods for determining thickness. (The microscopic method is specified in the standard, but when agreed upon the magnetic method or dropping test may be used. The appendix gives information on the latter two methods.)

It is of interest to note in connection with this emergency specification the paper presented at the Annual Meeting by Gustaf Soderberg dealing with properties of plated lead coatings on steel. The object of Mr. Soderberg, who was secretary of Committee B-8, is to assist users in choosing a proper type of coating for particular applications.

Pipe Specifications:

The emergency alternate provisions in the steel pipe specifications A 206 and A 158 are in general to make them comply with a master list of chemical compositions developed by a National Emergency Steel Specifications Technical Advisory Committee. These include provisions to conserve the supply of molybdenum and also in the case of EA - A 158 to concentrate production on a minimum number of steels. It should be noted from the accompanying page on which these provisions are published that none of the chemical requirements involved highly alloyed or stainless steels, but concern only compositions with less than 10 per cent chromium. While the committee in charge did make some recommendations with respect to the austenitic steels the particular concern was to have the emergency provisions issued on ferritic steels so that they might be referred to in a pending WPB limitation order to be part of L-211.

Friction Tape:

Committee D-11 on Rubber Products has developed a number of emergency alternate provisions to keep its specifications and test requirements in line with the wartime restrictions and deletion of the requirement in a previous emergency provision EA - D 69 that "The finished tape shall contain not more than 30 lb. of rubber hydrocarbon per 100 sq. yd. No new rubber shall be used in the manufacture of this tape," is in line with this objective.

EA - D 69a

(Standard Specifications for Friction Tape for General Use for Electrical Purposes (D 69 - 38))

Issued, July 20, 1943

This Emergency Alternate Provision modifies a previous Emergency Provision by deleting the requirement in Section 3 which provided that "the finished tape shall contain not more than 30 lb. of rubber hydrocarbon per 100 sq. yd. No new rubber shall be used in the manufacture of this tape."

EA - A 158

Issued, June 1, 1943

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Tentative Specifications for Seamless Alloy-Steel Pipe for Service at Temperatures from 750 to 1100 F. (A 158 - 42 T) and affect only the requirements referred to:

Section 1 (b).—Change the second sentence from its present form to read as follows:

Eight grades are covered, including five ferritic steels and three austenitic steels, designated P 5a, P 11, etc. (Note 1).

Note 1.—Add at the end of Note 1 the following sentence referring to the eleven grades of material normally covered:

During the Emergency the committee in charge of these specifications recommends that production be concentrated on the five emergency grades of ferritic steel and the three austenitic steels.

Table 1.—Change that portion of this table of chemical requirements which relates to ferritic steels to read as follows by the omission of ferritic steel grades P 3a, P 3b, P 5b, P 6, and P 15; and revision of grades P 5a, P 5c, and P 11; and the addition of grades EP 16 and EP 17. No changes are recommended in the austenitic steels.

TABLE 1.—CHEMICAL REQUIREMENTS.

Type.....	Ferritic Steels		
Identification Symbol.....	P 5a	P 5c	P 11
Grade.....	4 to 6 per cent Chromium	4 to 6 per cent Chromium-Molybdenum, Stabilized with Titanium or Columbium	Chromium-Molybdenum
Carbon, max., per cent....	0.15	0.12	0.15
Manganese, per cent.....	0.30 to 0.60	0.30 to 0.60	0.30 to 0.60
Phosphorus, max., per cent.....	0.04	0.04	0.04
Sulfur, max., per cent.....	0.04	0.04	0.04
Silicon, per cent.....	0.50 max.	0.50 max.	0.50 to 1.00
Chromium, per cent.....	4.00 to 5.50	4.00 to 5.50	1.00 to 1.50
Molybdenum, per cent.....	0.40 to 0.55	0.40 to 0.55	0.40 to 0.55
Titanium.....	.....	Min., per cent, 4 times the actual carbon; max., 0.70 per cent	.....

Type.....	Ferritic Steels	
Identification Symbol.....	EP 16	EP 17
Grade.....	7 per cent Chromium	9 per cent Chromium
Carbon, max., per cent....	0.15	0.15
Manganese, per cent.....	0.30 to 0.60	0.30 to 0.60
Phosphorus, max., per cent.....	0.04	0.04
Sulfur, max., per cent.....	0.04	0.04
Silicon, per cent.....	0.50 to 1.00	0.50 to 1.00
Chromium, per cent.....	6.00 to 7.50	8.00 to 9.50
Molybdenum, per cent.....	0.40 to 0.55	0.80 to 0.95
Titanium.....	.....	.....

EA - A 206

Issued, June 1, 1943

The following Emergency Alternate Provisions, when specified, may be used as an alternate in A.S.T.M. Tentative Specifications for Seamless Carbon-Molybdenum Alloy-Steel Pipe for Service at Temperatures from 750 to 1000 F. (A 206 - 42 T) and affect only the requirements referred to:

Section 5.—In the table of chemical composition requirements, change the requirements for molybdenum from "0.45 to 0.65 per cent" to read "0.40 to 0.55 per cent."

NEW MEMBERS TO JULY 15, 1943

EDITOR'S NOTE.—This list of new members which is by far the most extensive one ever given for the particular period covered does not give the new postal zones. However, a determined effort is being made to have the postal zones incorporated in the A.S.T.M. Year Book, copy for which is now in preparation, and lists of new members in future BULLETINS will include the zone information.

The following 123 members were elected from April 24 to July 15, 1943:

Chicago District

- AETNA BALL BEARING MANUFACTURING Co., J. J. Rozner, Chief Engineer and Chief Metallurgist, 4600 Schubert Ave., Chicago, Ill.
- APEX MACHINE Co., Nathan N. Kraus, Senior Development Engineer, 840 N. State St., Elgin, Ill.
- BUICK MOTOR DIVISION, GENERAL MOTORS CORP., O. N. Peterson, Melrose Park, Ill.
- DIAMOND T. MOTOR CAR Co., A. G. Danielson, Assistant Chief Engineer, 4401 W. Twenty-sixth St., Chicago, Ill.
- NATIONAL CONCRETE MASONRY ASSN., E. L. Dienhart, Executive Secretary, 33 W. Grand Ave., Chicago, Ill.
- REYNOLDS WIRE Co., L. H. McClendon, Chemist and Metallurgist, Dixon, Ill.
- VERMICULITE RESEARCH INST., Thomas H. Coulter, Secretary, 135s La Salle St., Chicago, Ill.
- WYMAN-GORDON Co., A. F. Christian, Chief Metallurgist, Harvey, Ill.
- ZENITH RADIO CORP., James F. Engle, Metallurgist, 6001 W. Dickens Ave., Chicago, Ill.
- FRANKLIN, RAYMOND J., Manager, Weld Rod and Development Div., The Chicago Hardware Foundry Co., North Chicago, Ill.
- GOTTSCALK, F. W., Technical Director, American Lumber and Treating Co., 332 S. Michigan Ave., Chicago, Ill.
- GUNIA, R. B., Manager, Stainless Steel Bureau, Metallurgical Div., Carnegie-Illinois Steel Corp., 208 S. LaSalle St., Chicago, Ill.
- SHAKMAN, J. G., Vice-President, Pabst Brewing Co., 221 N. LaSalle St., Chicago, Ill.

Cleveland District

- COPPERWELD STEEL Co., W. J. Buechling, Chief Metallurgist, Mahoning Ave. Extension, Warren, Ohio.
- COSMA LABORATORIES Co., THE, R. W. Frischmuth, Assistant Technical Director, 1545 E. Eighteenth St., Cleveland, Ohio.
- KALTENBACH CORP., R. W., E. J. Kaltenbach, First Vice-President, Box 1780, Newburgh Station, Cleveland, Ohio.
- MONARCH ALUMINUM MANUFACTURING Co., 9301 Detroit Ave., Cleveland, Ohio.
- CHIAVETTA, KENNETH J., Metallurgist, National Aluminum
- Cylinder Head Co., Cleveland, Ohio. For mail: 9725 Heath Ave., Cleveland, Ohio. [J]*
- GORDON, PHILLIP, Materials and Process Engineer, Good-year Aircraft Corp., Department 38, Plant B, Akron, Ohio. [J]
- HOTTEL, H. H., Metallurgical Engineer, Youngstown Sheet and Tube Co., Youngstown, Ohio.
- KESSLER, JOSEPH C., Foreman of Test Lab., Aluminum Co. of America, Cleveland, Ohio. For mail: 5513 Garden St., Maple Heights, Ohio. [J]

Detroit District

- SPARKS-WITHINGTON Co., THE, Leslie I. Steinbach, Manager, Plant No. 5, E. Michigan and Horton Sts., Jackson, Mich.
- STEVENS, INC., FREDERIC B., L. Ralph Eastman, Manager, Buffing Composition Dept., 510 3rd St., Detroit, Mich.
- GAMMEL, WALTER ARTHUR, Associate Inspector of Ordnance
- Materials, War Dept., Detroit Ordnance District, Detroit, Mich. For mail: Box 82, East Lansing, Mich. [J]
- KRUEGER, FREDERICK, Chemist and Metallurgist, Ford Motor Co., River Rouge Plant, Dearborn, Mich. For mail: 672 Marlborough, Detroit, Mich. [J]
- McKINNON, DONALD J., Me-

chanical Engineer, Detroit Steel Products Co., 2250 E. Grand Boulevard, Detroit, Mich.

New York District

- INDUSTRIAL SYNTHETICS CORP., Albert A. Kaufman, Vice-President, 60 Woolsey St., Irvington, N. J.
- INTERNATIONAL PROJECTOR CORP., W. G. Bjorkstedt, Metallurgist, 92 Gold St., New York, N. Y.
- KEUFFEL & ESSER Co., Carl W. Keuffel, Secretary, 300 Adams St., Hoboken, N. J.
- MANUFACTURERS CHEMICALS CORP., Samuel P. Zuccarelli, Chemist, Berkeley Heights, N. J.
- NORDERN, INC., CARL L., Ulric R. Jaeger, Materials Engineer, 80 Lafayette St., New York, N. Y.
- ROSEMARY SALES, Robert Taft Pullar, Director of Research, 40 Worth St., New York, N. Y.
- ZOPHAR MILLS, INC., A. Saunders, Technical Director, 112 Twenty-sixth St., Brooklyn, N. Y.
- CHATENEVER, ALFRED, Senior Chemist, Matam Corp., Long Island City, N. Y. For mail: 8320 Bay Parkway, Brooklyn, N. Y.
- GOLD, HOWARD G., Associate Mechanical Engineer, Fort Monmouth Signal Lab., Fort Monmouth, Red Bank, N. J. For mail: 370 Broadway, Bayonne, N. J. [J]
- GOMEZ, WILLIAM, Designing Draftsman, The M. W. Kellogg Co., New York, N. Y. For mail: 1425 Hobart Ave., New York, N. Y. [J]
- GOTTLIEB, SAUL, Analytical
- Chemist, Matam Corp., Long Island City, N. Y. For mail: 1911 University Ave., Bronx, New York, N. Y.
- HALLER, ELLIOT A., Manager, The Haller Engineering Associates, Inc., New York, N. Y. For mail: 314 E. Forty-first St., New York, N. Y.
- KROL, ADAM T., Chief Research Chemist, Matam Corp., Long Island City, N. Y. For mail: 548 Park Ave., Yonkers, N. Y.
- LEVINSON, SYDNEY B., Chemist, A. C. Drubel Co., Inc., 150 Rome St., Newark, N. J.
- MARVIN, PHILIP ROGER, Chief Metallurgical Engineer, Bendix Aviation Corp., Marine Div., 754 Lexington Ave., Brooklyn, N. Y.
- McINTYRE, WILLIAM H., Assistant Technical Director, American Mineral Spirits Co., 155 E. Forty-fourth St., New York, N. Y.
- PALMER, J. E., Supplies Inspection Superintendent, Western Electric Co., Inc., 395 Hudson St., New York, N. Y.
- PRICE, JOHN R., Machine Shop Superintendent, Madison Iron Works, Inc., Madison, N. J. For mail: Box 21, Madison, N. J.
- SKEHAN, JOSEPH W., Factory Manager, Machlett Laboratories, Inc., Springdale, Conn.
- WEYL, ERIC, Textile Engineer, Textile Industry Research, Inc., New York, N. Y. For mail: 64-33 Ninety-eighth St., Forest Hills, L. I., N. Y.

Northern California District

- CHEMURGIC CORP., C. H. Harris, Vice-President, Giant Road, Richmond, Calif.
- BARGIONI, L. G., Secretary, Smith, Emery and Co., 651 Howard St., San Francisco, Calif.
- CAMPBELL, WILLIAM EUGENE, Assistant Resident Engineer In Charge of Construction,
- Public Works Dept., Bureau of Yards and Docks, Navy Dept., Moffett Field, Calif. For mail: 296 N. Third St., San Jose, Calif.
- POLIVKA, JARO J., Research Associate and Consulting Engineer, Engineering Materials Lab., University of California, Berkeley, Calif.

Philadelphia District

- COLEMAN, J. FRED, JR., District Materials Engineer, Pennsylvania State Highways Dept., Harrisburg, Pa. For mail: Hamilton Court Apartments, 113 Cricket Ave., Ardmore, Pa.
- GREENHALGH, ALBERT E.,
- Chemist, Allied Chemical and Dye Corp., Bridesburg, Philadelphia, Pa. For mail: 5110 N. Fairhill St., Philadelphia, Pa.
- MARINCAS, JOHN GEORGE, Tool and Die Heat Treater, Eastern Aircraft, Trenton Division,

General Motors Corp., Trenton, N. J. For mail: 39 Howard St., Trenton, N. J. [J]

PRATT, W. G., Chief Estimator, Edge Moor Iron Works, Inc., Edge Moor, Del. For mail:

Box 38, Thorndale, Pa.

WILLIAMS, E. C., Vice-President, In Charge of Research, General Aniline and Film Corp., Central Research Lab., Lincoln and Coal Sts., Easton, Pa.

Pittsburgh District

AMERICAN WINDOW GLASS CO., A. S. Crandon, Executive Vice-President, In Charge of Operations, 1617 Farmers Bank Bldg., Pittsburgh, Pa.

THOMPSON AND CO., D. D. Munroe, Vice-President, 1085 Allegheny Ave., Oakmont, Pa.

VULCAN SOOT BLOWER CORP., D. E. Hibner, Jr., Chief Engineer, Du Bois, Pa.

BARR, NAAMAN F., Chemist, Stoner Mudge, Inc., Pittsburgh, Pa. For mail: 4 N. Sprague Ave., Pittsburgh, Pa.

GETTING, MILAN, JR., Superin-

tendent, Test Dept., Allis-Chalmers Manufacturing Co., Pittsburgh Works, Pittsburgh, Pa.

KEENE, WALTER L., Manager, Metallurgical Dept., Superior Steel Corp., Carnegie, Pa.

REILLEY, EDWARD M., JR., Assistant Chief Inspector, Ordnance Dept., U. S. Army, 901 S. Negley Ave., Pittsburgh, Pa.

TARNOPOL, MILTON S., Research Engineer, Pittsburgh Plate Glass Co., 4337 Fifth Ave., Pittsburgh, Pa.

St. Louis District

ALLIS-CHALMERS MANUFACTURING CO., G. W. Klumpp, Metallurgist, Springfield, Ill.

POLLARD, WILLIAM CARL, Chemist, Amertorp Corp.,

St. Louis, Mo. For mail: 5138 Washington Boulevard, St. Louis, Mo. [J]

VON FUCHS, GEORGE HUGO, Consulting Chemist, Shell Oil Co., Inc., Wood River, Ill.

Southern California District

BATE, JOHN F. L., Field Engineer, Consolidated Vultee Aircraft Corp., San Diego Div., Plant Engineering Dept., Plant No. 2, Lind-

berg, Field, San Diego, Calif. NORTON, FORREST A., Principal Engineer Aide, U. S. Engineer Office, 751 S. Figueroa St., Los Angeles, Calif.

Western New York-Ontario District

ADAIR, ROBERT V., Metallurgist, Gleason Works, Rochester, N. Y.

BITTENBENDER, ROBERT A., Structural Engineer, Curtiss-Wright Corp., Airplane Div., Airport Plant, Buffalo, N. Y. For mail: 220 Summer St., Buffalo, N. Y. [J]

FINDLEY, J. K., Metallurgical Engineer, Allegheny-Ludlum Steel Corp., Dunkirk, N. Y.

For mail: E. Main Road, R.F.D. 2, Dunkirk, N. Y.

NEWTON, VICTOR A., Junior Mechanical Engineer, Sterling Engine Co., Buffalo, N. Y. For mail: 538 Linwood Ave., Buffalo, N. Y. [J]

ROBINSON, G. ELLIOTT, Structural Engineer, Curtiss-Wright Corp., Structures Dept., Plant No. 2, Buffalo, N. Y.

U. S. and Possessions

Other than A.S.T.M. Districts

AVRIL SMELTING WORKS, G. A., George A. Avril, Proprietor, Este Ave. and B. & O.R.R., Cincinnati, Ohio.

BLUE RIDGE GLASS CORP., J. H. Lewis, Assistant General Manager, Kingsport, Tenn.

EMERY INDUSTRIES, INC., J. L. Trauth, Jr., Chief Chemist, 4300 CAREW TOWER, Cincinnati, Ohio.

FAIRCHILD, AIRCRAFT DIVISION OF FAIRCHILD ENGINE AND AIRPLANE CORP., M. J. Frank, Chief of Labs., Test Lab.,

Plant No. 2, Hagerstown, Md.

HARTFORD ELECTRIC STEEL CORP., THE, John H. G. Williams, Metallurgist, 540 Flatbush Ave., Hartford, Conn.

LILLY VARNISH CO., H. B. Currens, Chief Chemist, 673 S. California St., Indianapolis, Ind.

NEW PRODUCTS CORP., Walter Miller, President, 448 North Shore Drive, Benton Harbor, Mich.

OGDEN IRON WORKS CO., James W. Silver, President, Box 147, Ogden, Utah.

RAYTHEON MANUFACTURING CO., POWER TUBE DIVISION, Harry T. Pekin, Chief Design Engineer, 12 Foundry Ave., Waltham, Mass.

ROLLWAY BEARING CO., INC., J. E. Sero, Chief Engineer, 541 Seymour St., Syracuse, N. Y.

UNITED AIRCRAFT PRODUCTS, INC., Ada M. Clark, Material Control, 480 Huffman Ave., Dayton, Ohio.

WARNER GEAR DIVISION, BORG-WARNER CORP., Robert J. Peters, Chief Metallurgist, 1108 E. Seymour St., Muncie, Ind.

WATSON-PARK CO., Frederic A. Prisley, Chemist, Vallardvale, Mass.

WAYNE PUMP CO., THE, R. J. Jauch, Manager, Experimental Dept., Fort Wayne, Ind.

WINCHARGER CORP., R. E. Smith, Research and Development Engineer, E. Seventh and Division Sts., Sioux City, Iowa.

WORCESTER AND CO., J. R., Thomas Worcester, Partner, 79 Milk St., Boston, Mass.

BACON, WILLIAM VAN V., Test Engineer, Westvaco Chlorine Products Corp., P. O. Drawer J, South Charleston, W. Va.

DOANE, LEWIS B., Chief Engineer, Electric Boat Co., Groton, Conn.

EGY, W. L., General Manager, Zenith Optical Co., 220 Eighth St., Huntington, W. Va.

GALLAGHER, ARTHUR, Chemist, Hayward-Schuster Woolen Mills, East Douglas, Mass.

GENTRY, CHARLES ROGERS, Test Engineer, General Electric Co., Lynn, Mass. For mail: 37 Park St., West Lynn, Mass. [J]

GRINER, A. J., Owner, A. J. Griner Co., 417 E. Thirteenth St., Kansas City, Mo.

GUISE, ARTHUR B., Vice-President, DuGas Engineering Corp., Marinette, Wis.

HAHNER, C. H., Chief, Glass Section, National Bureau of Standards, Washington, D. C.

KOPP, PAUL J., Major, Office of the Chief of Chemical Warfare Service, Washington, D. C. For mail: 2515 K St., N. W., Washington, D. C.

LADDO, RAYMOND B., Consulting Engineer, 42 Huntington Road, Newton, Mass.

MCCUNE, WILLIAM J., JR., Manager, Quality Control Dept., Polaroid Corp., 211 Massachusetts Ave., Cambridge, Mass.

MEIGS, DOUGLAS P., Chemical Engineer, American Instrument Co., Box 485, Silver Spring, Md.

MELROSE, ADOLPH E., Research Engineer, Hastings Manufacturing Co., Hastings, Mich.

MOORE, BYRD L., Office Paving Engineer, Pan American Airways, Inc., 1024 du Pont Bldg., Miami, Fla.

MULLEN, E. G., Technical Director, Scutan Div., Union Bag and Paper Corp., Hudson Falls, N. Y. For mail: 1 Rogers St., Hudson Falls, N. Y.

RAVICH, LEONARD E., Chief Chemist, Royal Typewriter Co., Inc., 150 New Park Ave., Hartford, Conn.

ROSENFELD, MYER, Associate Chemist, War Ordnance, Automotive Div., Proving Center, Aberdeen, Md. For mail: 5043 Chalgrove Ave., Baltimore, Md.

ROYAL AUSTRALIAN AIR FORCE REPRESENTATIVE, A. N. Hocking, Wing Commander, 4509 Munitions Bldg., Constitution Ave., N. W., Washington, D. C. (Two additional memberships are in effect with the same address)

SMITH, THOMAS R., Superintendent, Yarn Dyeing Dept., Wiscasset Mills Co., Albemarle, N. C.

TOWERY, JACK D., Textile Engineer, Cotton Research Committee of Texas, University of Texas, Austin, Tex. For mail: 1506-D Guadalupe, Austin, Tex. [J]

VALLEY, ROBERT N., Paint Inspector, Office of Supervisor of Shipbuilding, U. S. Navy, 22 Virginia Court, New Orleans, La.

WHITESIDES, GEORGE W., Technical Director, Solvents and Plastics Co., Louisville, Ky. For mail: Box 18, Anchorage, Ky.

WILLIAMS, SIMON, Director of Research, National Cotton Council of America, 69 Union, Memphis, Tenn.

WINDER, JOSEPH Z., Engineer, The Richmond Fireproof Door Co., Box 306, Richmond, Ind.

WORCESTER FREE PUBLIC LIBRARY, 12-18 Elm St., Worcester, Mass.

Other than U. S. and Its Possessions

CELLOMOLD, LTD., L. M. Read, Works Manager, Browell's Lane, Feltham, Middlesex, England.	Empire Brass Manufacturing Co., Ltd., London, Ont., Canada.
JOHNSON MATTHEY AND CO. (CANADA), LIMITED, R. Y. Ward, Chief Chemist, 198 Clinton St., Toronto, Ont., Canada.	PLANTA METALURGICA NA- CIONAL DE MEDELLIN, Medel- lin, Colombia. PLANTA METALURGICA NA- CIONAL DE PASTO, Pasto, Col- ombia.
CLEAVE, DENNIS PERCY COLIN, Chemist, 41 Westfield Road, Barnhurst, Kent, England. [J]	WRIGHT, WILLIAM GEORGE, Proprietor, Wright and Co., 81 Clarence St., Sydney, N.S.W., Australia.
IVEY, C. H., Purchasing Agent,	* [J]—Denotes Junior Member.

Personals

... News items concerning the activities of our members will be welcomed for inclusion in this column.

CHARLES B. THOMPSON, who was Senior Inspector of Ordnance Material, St. Louis Ordnance Plant, St. Louis, Mo., is now Assistant to Military Chief Engineer, Office of Chief of Ordnance, Small Arms Ammunition Suboffice, War Department, Philadelphia, Pa.

LLOYD F. RADER is now U. S. Naval Reserve, Training Officer, Camp Rousseau, Advance Base Depot, Port Hueneme, Calif. He was formerly stationed at Williamsburg, Va.

THADDEUS J. ARMSTRONG, who was Tool and Machine Designer, Foote Bros. Gear and Machine Corp., Chicago, Ill., is now Superintendent of Inspection Equipment Design, Illinois Division, Bendix Aviation Corp., Chicago, Ill.

EUGENE D. BECKER is now Chemical Engineer, Taylor Instrument Cos., Rochester, N. Y.

W. T. BROWN, who was formerly Research Engineer, is now Manager, Coal, Coke and By-Products Research Department, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

LEO DANZKER is Junior Chemical Engineer, The B. F. Goodrich Co., Akron, Ohio. He was formerly Assistant Specifications Specialist, Product Control Division, Nebraska Defense Corp.

EARL C. SUTHERLAND, formerly Associate Highway Engineer, Public Roads Administration, Division of Tests, Washington, D. C., is now Senior Highway Engineer.

FRANCIS A. McADAM is now with the Concrete Materials Section, War Production Board, Washington, D. C. He was formerly Director of Research, Southern States Portland Cement Co., Rockmart, Ga.

T. G. DELBRIDGE, Manager, Research and Development Dept., The Atlantic Refining Co., Philadelphia., is chairman of the Technical Advisory Committee of 20 members which is a subdivision of the Petroleum Industry War Council.

W. J. GILSON, General Manager, Eastern Power Devices, Ltd., Toronto, Ontario, Canada, was elected at the recent annual meeting as one of the vice-presidents of the American Institute of Electrical Engineers, for the year beginning August 1.

ELMER GAMMETER, formerly Manager, Stainless Steel Bureau, Metallurgical Dept., Chicago District, Carnegie-Illinois Steel Corp., Chicago, Ill., is now Chief Metallurgist, Globe Steel Tubes Co., Milwaukee, Wis.

WINSLOW H. HERSHEL has retired as Associate Materials Engineer of the National Bureau of Standards, Washington, D. C.

GEORGE L. LUCAS, formerly Engineer of Inspection, The Port of New York Authority, New York, N. Y., is now Consulting Engineer, New York, N. Y.

L. W. WALTER, who was Consultant on Concrete, Jersey City, N. J., is now Naval Architect, U. S. Maritime Commission, Gulf Coast Regional Construction Office, New Orleans, La.

GUSTAF SODERBERG, who represents The Udylite Corp. in its sustaining membership in A.S.T.M., is now with the War Production Board in Washington, D. C.

The metallurgical laboratories that were established by SAM TOUR during the 14 years he has been Vice-President and Chemical and Metallurgical Engineer of Lucius Pitkin, Inc., now located at 45 Fulton St., will be operated as the laboratories of Sam Tour & Co., Inc. Lucius Pitkin, Inc., will continue as before as analysts, assayers, chemists, spectroscopists, consultants, etc., particularly in the mining and metallurgical fields. Sam Tour & Co., Inc., with main offices at 65 Pine St., New York, N. Y., and laboratories at 45 Fulton St., will specialize in the metallurgical, chemical and process engineering field.

FRANK L. WRIGHT, formerly Chief Metallurgist, Norm-Hoffman Bearings Corp., Stamford, Conn., has been advanced to the position of Manager of Research.

C. C. SNYDER, who has been with the Conservation Division, War Production Board for eight months has returned to active duty with Republic Steel Corp. His address is Republic Steel Corp., 1625 K St., N. W., Washington 6, D. C.

ARTHUR D. LITTLE, INC., Chemists and Engineers, Cambridge, Mass., has a new street address—30 Memorial Drive—instead of the former Charles River Road, Kendall Square. Their location remains the same—only the name of their street has been changed.

At the 189th Commencement of Columbia University on June 1, two A.S.T.M. members were honored, as follows: the honorary degree of Doctor of Science was conferred upon CHARLES F. KETTERING, Vice-President, General Motors Corp., Research Laboratories, Detroit, Mich.; and GUSTAV EGLOFF, Technical Director, Universal Oil Products Co., Chicago, Ill., received a University Medal.

At the annual meeting of the American Foundrymen's Association several A.S.T.M. members were elected to office, as follows: LEE C. WILSON, General Manager, Reading Steel Casting Division, American Chain and Cable Co., Inc., Reading, Pa., as President; RALPH J. TEETOR, President, Cadillac Malleable Iron Co., Cadillac, Mich., as Vice-President; MAX KUNIAN-SKY, General Manager, Lynchburg Foundry Co., Lynchburg, Va., WILLIAM B. WALLIS, President, Pittsburgh Lectromelt Furnace Corp., Pittsburgh, and DUNCAN P. FORBES, President, Gunite Foundries Co., Rockford, Ill., as Directors for three-year terms.

S. H. GRAF, Professor of Mechanical Engineering and Director of Engineering Research, Oregon State College, Corvallis, Ore., was nominated as a Manager of The American Society of Mechanical Engineers at its recent semi-annual meeting.

At the annual election of officers of the New York Paint and Varnish Production Club two A.S.T.M. members were honored as follows: Vice-President: FREDERICK M. DAMITZ, President, National Varnished Products Corp., Rahway, N. J.; and Secretary: ROBERT D. BONNEY, Assistant Manager of Manufacturing, Congoleum-Nairn, Inc., Kearny, N. J.

ROBERT E. WILSON, President, Pan American Petroleum and Transport Co., New York, N. Y., received the honorary degree of Doctor of Laws from Colby College at its 122nd commencement. He delivered the commencement address on "Individuals and Incentives," stressing the necessity of maintaining properly balanced incentives for labor, management, and capital if our past rate of progress is to be continued.

ALFRED H. WHITE, Professor of Chemical Engineering, University of Michigan, Ann Arbor, Mich., together with Mrs. White, was recently honored when 350 friends and neighbors, former students, faculty and professional associates joined them at a dinner at the Michigan Union Building in Ann Arbor to celebrate his seventieth birthday. That date also signaled some 50 years of association with the University for Dr. White.

This column records somewhat belatedly that H. C. BOARDMAN, Research Engineer, Chicago Bridge and Iron Co., Chicago, Ill., gave the commencement address (Jan. 29, 1943) at the South Dakota School of Mines, Rapid City, S. D., and at that time the honorary degree of Doctor of Engineering was conferred upon him.

At the third annual meeting of the American Industrial Radium and X-ray Society, Inc., held in Pittsburgh on June 29, the two annual lectures were presented, one dealing with Gamma-ray work and the other with X-ray work, which features have been named in honor of two outstanding authorities and pioneers in this work—R. F. MEHL, Director, Metals Research Laboratory, Carnegie Institute of Technology, Pittsburgh, Pa., and H. H. LESTER, Senior Physicist, Watertown Arsenal, Watertown, Mass. Messrs. Mehl and Lester have been extremely active in A.S.T.M. work. Dr. Mehl was the moving spirit behind the 1936 A.S.T.M. Symposium on Radiography and X-ray Diffraction, while Dr. Lester is Chairman of Committee E-7 and an outstanding pioneer in radiographic work. Much of the important development work and the publication and discussion sponsored by Committee E-7 trace to his enthusiastic support.

CHARLES F. DUCHACEK, formerly Junior Engineer, M. R. Scharff, Consulting Engineer, New York, N. Y., is now Chemical Engineer, Arabol Manufacturing Co., Brooklyn, N. Y.

C. R. BAKER is now Chief, Production Planning and Service, Pacific Tube Co., Los Angeles, Calif. He was formerly Supervisor of Specifications, National Tube Co., Ellwood City, Pa.

W. F. BROWN, who was Manager, Production and Material Control, Missouri Valley Bridge and Iron Co., Shipbuilding Division, Evansville, Ind., is now connected with Bell Aircraft Corp., Buffalo, N. Y.

JAMES T. KEMP is now Metals Adviser, Production Branch, Headquarters Services of Supply, U. S. Army, Washington, D. C.

E. H. BUCY, who has been very active as Chief of the Protective Coatings Branch of the War Production Board, has returned to his company, Atlas Powder Co., as Assistant General Manager of the Cellulose Products Department, Wilmington, Del. He was formerly Technical Director of the Zapon Division at Stamford, Conn.

MURRAY F. SKINKER, formerly Chief Development Engineer, Selenium Rectifier Division, Federal Telephone and Radio Corp., East Newark, N. J., is now Manager of the Rectifier Department.

LAWFORD H. FRY, formerly Railway Engineer, Edgewater Steel Co., Pittsburgh, Pa., and previous to that associated for many years with The Standard Steel Works and The Baldwin Locomotive Co., has recently become Director of Research, Locomotive Institute, New York, N. Y. Mr. Fry, who has been extremely active in A.S.T.M. work, particularly in Committee A-1 on Steel, is at present a member of the A.S.T.M. Executive Committee. In his new position he will be directly concerned with many problems involving locomotive design under the jurisdiction of the Institute's Technical Committee. In order that these studies which have had a number of encouraging results should continue and because the technical staffs of locomotive builders have been concentrating on problems of construction involving war matériel, the new office of Director of Research has been established. Mr. Fry's duties will include an analysis of studies already under way and investigation of accomplishments that have improved the performance of the steam locomotive so much in recent years.

C. E. SKINNER, who retired a number of years ago as Assistant Director of Engineering, Westinghouse Electric and Manufacturing Co., has, since April 1, been attached to the Executive Office of the Director of Fort Monmouth, Signal Laboratory, of the U. S. Army Signal Service, as a civilian engineer. In acknowledging his award of a certificate as one of the 18 forty-year members, Mr. Skinner advised that he was putting in his 48 hours per week and some added over-time, and enjoying his work, which is really a most interesting statement considering the fact that he lacks just two years of being at four score.

JOHN B. MACAULEY, JR., formerly Research Engineer, Chrysler Corp., Detroit, Mich., is now Engineer, Pratt & Whitney Division, United Aircraft Corp., East Hartford, Conn.

ARTHUR N. REECE, who has been Chief Engineer of Kansas City Southern Railway, Kansas City, Mo., for many years is now Assistant to the President.

EVERETT J. RUTAN is connected with Sherman, Boland & Boyce, Industrial Consultants, New York, N. Y., as Electrical Engineer. He was formerly Engineer, Chemical Construction Corp., New York, N. Y.

M. VIRGINIA SINK, formerly Spectrographic Engineer, Chrysler Corp., Highland Park, Mich., is now Supervisor of Laboratory Women.

At the annual meeting of the American Institute of Chemists in May FRANK G. BREYER, Singmaster & Breyer, New York, N. Y., was reelected a councillor to serve through May, 1946. At this same meeting, R. J. MOORE, Manager, Development Laboratories, Bakelite Corp., Bloomfield, N. J., presented an interesting paper dealing with synthetic resin plastics, which is published in the May issue of *The Chemist*, the A.I.C. journal.

SELIG WILNER, formerly Materials Engineer, Federal Works Agency, Work Products Administration, is now Metallurgical Supervisor, Remington Rand, Inc., Propeller Division, Johnson City, N. Y.

HANS FRIEDRICH WINTERKORN is now connected with Princeton University, Princeton, N. J., as Associate Professor of Civil Engineering, Department of Civil Engineering. He was formerly Associate Professor of Civil Engineering, University of Missouri, Columbia, Mo.

H. S. MATTIMORE, formerly Engineer of Materials, Pennsylvania State Highway Department, Harrisburg, Pa., is now Senior Civil Engineer, Civil Engineering Corps, U. S. Navy, Wilmington, N. C.

Gas Association Issues Standards for Light Oil Products

A NEW BOOK WHICH will undoubtedly be of interest to numerous A.S.T.M. members is the *Gas Chemists' Book of Standards for Light Oils and Light Oil Products* by V. J. Altieri, published by the American Gas Association, 420 Lexington Avenue, New York.

The book is particularly pertinent also because of a new A.S.T.M. standing committee now being organized to cover the field of aromatic hydrocarbons in which field a number of the tests included in the *Gas Chemists' book* have application.

The A.G.A. subcommittee on revision of the handbook includes a number of A.S.T.M. members active in various phases of the work in materials. In expediting this work the committee was cognizant of the importance of quality involving large quantities of benzene, light oils, and numerous other products. The book includes a great deal of new material on account of recent developments for fractional distillation, analysis, and covers fundamentals involving specifications, definitions, tests, etc. The first part of the book includes a number of specifications. Part two refers to definitions of terms, and an extensive section covers methods for sampling and tests. An appendix includes helpful related information and considerable tabular data. There is a very complete subject index.

It is of interest that the author has used considerable A.S.T.M. material, some of the tests are indicated as being identical with certain A.S.T.M. standards, and the style of the book as the author indicates is based on format and style of the 1942 Book of A.S.T.M. Standards.

Copies of this 372-page book in blue cloth binding can be obtained from the office of the American Gas Association, \$3.50 to A.G.A. Members and \$5.00 to Non-Members.

NECROLOGY

We announce with regret the death of the following members:

EDWIN M. BAKER, Professor of Chemical Engineering, University of Michigan, Ann Arbor, Mich. Member since 1937. At the time of his death Professor Baker was serving as Chairman of Committee B-8 on Electrodeposited Metallic Coatings, and represented that committee on the Advisory Committee on Corrosion. He was also a member of Committee A-5 on Corrosion of Iron and Steel and Subcommittee VII on Methods of Testing. Prof. Baker was a past-president of the American Electroplaters' Society and had taken a very prominent part in the organization of Committee B-8. He was an outstanding authority in the electroplating field and contributed much to the work of this A.S.T.M. committee. His sudden death was a distinct shock to his many associates.

ARTHUR E. ELLIS, Principal Chemist, I. R. T. Division, New York City Transit System, Board of Transportation, New York, N. Y. Member since 1919.

EDMUND S. GARDNER, President, The Hartford Electric Steel Corp., Hartford, Conn. Member since 1937.

ROBERT W. KALTENBACH, President, R. W. Kaltenbach Corp., Cleveland, Ohio. Member since 1929.

E. F. KENNEY, Metallurgical Engineer, Bethlehem Steel Co., Inc., Bethlehem, Pa. (See accompanying note.)

W. E. SCHLUETER, Branch Manager, The Refinery Supply Co., Inc., Houston, Tex. Junior Member since 1940. Mr. Schlueter was the son of W. A. Schlueter, President of Refinery Supply Co., in Tulsa. He had become a member of the U. S. Navy Air Reserve Service and his plane crashed while on maneuvers. The records of the U. S. Navy include after his name the tribute, "Died in Line of Duty."

EMORY E. SMITH, President and General Manager, Smith, Emery and Co., San Francisco Calif. Member since 1906. (See accompanying note.)

WILLIAM J. WOOLDRIDGE, Sales Engineer (Retired), Allegheny Ludlum Steel Corp., Brackenridge, Pa. Member since 1923. Mr. WOOLDRIDGE was a member of Committee A-6 on Magnetic Properties and Subcommittee IV on Alternating Current Test Methods.

JOSEPH R. WORCESTER, Civil Engineer, Boston, Mass. Member since 1904.

E. F. Kenney (1869-1943)

The death on July 8 after an illness of several months of E. F. Kenney, Metallurgical Engineer, Bethlehem Steel Co., Bethlehem, Pa., removes from the ranks of long-time members of the Society one who for almost 40 years had participated actively in many phases of Society work, especially those involving Committee A-1 on Steel. Late last winter Mr. Kenney suffered a heart attack from which he never recovered, although up until the past two months he had been reporting to his office regularly. An outstanding authority on the production and use of rails and track accessories, Mr. Kenney, following his early industrial experience with the Pennsylvania Railroad, became Metallurgical Engineer for the Cambria Steel Co., and was serving in this capacity when he joined the Society in 1904. He continued with Cambria when the company was operated by The Midvale Steel and Ordnance Corp. during the last World War, and then Mr. Kenney became Metallurgical Engineer of the Bethlehem Steel Co. Perhaps his most notable service in the Society has been the chairmanship of Committee A-1's Subcommittee I on Steel Rails and Accessories since it was formed in 1912, but he was active in the work involving many other steel products. A long-time member of the A-1 Advisory Committee, he had been producer vice-chairman since 1926. Some of his early activities in the Society included also work in the committees on wrought iron, corrosion of iron and steel, and he also represented his company on Committee D-3 on Gaseous Fuels. Mr. Kenney served as a member of the Society's Executive Committee from 1925 to 1927 and also was for five years a member of the important Committee

E-10 on Standards. He was also concerned with the work of other groups and with some committees functioning under the procedure of the American Standards Association. For a great many years he had been active in the work of the Association of Steel Manufacturers Technical Committees, and later the work of the American Iron and Steel Institute where he was chairman of several technical groups. At the June, 1943, meeting of Committee A-1 on Steel in recognition of his notable service he was elected honorary vice-chairman, which office he held only a few days because of his death.

During the early and sometimes trying formative years of the Society and in the later periods when there were so many problems in connection with standardization and research involving steel and its products, and in fact throughout his Society life, Mr. Kenney rendered notable service on many occasions. His many associates in A.S.T.M. work will keenly regret his passing. In these brief notes of his work, the Society also records its appreciation of his many services.

Emory Evans Smith (1863-1943)

In the sudden death of Emory Evans Smith on May 4 in San Francisco the Society loses a long-time member affiliated with A.S.T.M. since 1906 and one who had been a pioneering leader in the inspection and testing field. Co-founder of the firm of Smith, Emery & Company in San Francisco, he had since its organization in 1904 taken an active part in many important Western projects. During the First World War he was Commissioner-at-large in charge of steel mills, foundries, and scrap yards, and earlier in his career had been a Professor of Agriculture at Stanford University, was active as a newspaper editor, and throughout his life was active in fraternal, civic, and social organizations. In A.S.T.M. he had been affiliated continuously with Committee C-1 on Cement for some 30 years.

Catalogs and Literature Received

FISH-SCHURMAN CORP., 230 East 45th St., New York 17, N. Y. A four-page leaflet, OC292, describing the Fish-Schurman Optical Contour Comparator for visual comparison and measurement. Illustrated.

C. J. TAGLIABUE MFG. CO., Park and Nostrand Aves., Brooklyn 5, N. Y. A new catalog, Number 1200, entitled "TAG Indicating and Recording Controllers for Temperature and Pressure," a 40-page book giving a comprehensive presentation of three types of controllers—On-Off, Throttling, and Automatic Reset. The many illustrations show how these pressure-spring controllers operate.

CARL SCHLEICHER & SCHUELL CO., 116-118 West 14th St., New York, N. Y. A 15-page booklet entitled "S & S Reference Tables for Filtrations in Methods of Chemical Analysis," giving extensive tables comprising a filtration guide, and other details.

AMERICAN INSTRUMENT CO., 8010-8020 Georgia Ave., Silver Spring, Md. A four-page folder, Bulletin 2115, covering a "new precision instrument for measuring gloss—the Aminco-Scott Glossmeter (Goniophotometer)."

W. H. & L. D. BETZ, Gillingham and Worth Sts., Frankford, Philadelphia, 24, Pa. A ten-page booklet entitled "TAPPI Survey of Water Technology, 1942" by Lewis B. Miller—Technical Paper No. 86. Gives sections covering A—water in the war production program; B—water—the raw material; C—process water for industry; D—water treatment; E—water analysis; F—corrosion; G—boiler feedwater and cooling water; H—bacteriology and biochemistry of water; I—equipment; J—recent books on water and related subjects.

LEEDS & NORTHRUP CO., 4907 Stenton Ave., Philadelphia 44, Pa. An eight-page folder, Catalog E-53 (1) (replacing Bulletin 434) entitled "Students' Kelvin Bridge and Accessories." This instrument provides the features found valuable in imparting an understanding of the Kelvin bridge method. Illustrated.

FEDERAL PRODUCTS CORP., 1144 Eddy St., Providence 1, R. I. A four-page illustrated folder, describing the Testmaster (Universal) Dial Indicator.

Complete List of A.S.T.M. Emergency Specifications and Emergency Alternate Provisions

EDITOR'S NOTE.—To provide a readily accessible and convenient reference for members who wish to have a complete list of all emergency specifications and emergency alternate provisions (pink slips) each issue of the BULLETIN will give the latest list at the time the BULLETIN goes to press. This feature suggested by the Executive Committee will appear as the last page or two of BULLETIN text immediately preceding the professional card page in the back advertising section.

July 20, 1943

Emergency Specifications for¹

- ES-1a Lead-Coated and Lead-Alloy Coated Copper Wire for Electrical Purposes.
- ES-2 Lead Coating (Hot-Dip), on Iron or Steel Hardware.
- ES-3 Conducting Salt Spray Tests on Organic Protective Coatings. (Method)
- ES-4 *Discontinued*, Replaced by Standard Hardness Conversion Table for Cartridge Brass. (Relationship Between Diamond Pyramid Hardness, Rockwell Hardness, and Brinell Hardness) (E 33-42)
- ES-5a Carbon-Chromium Ball and Roller-Bearing Steels.
- ES-6 Rubber Sheath Compound for Electrical Insulated Cords and Cables Where Extreme Abrasion Resistance Is Not Required.
- ES-7 Fire-Refined Copper for Wrought Products and Alloys.
- ES-8 85 Per Cent Magnesia Thermal Insulating Cement.
- ES-9 Long Fiber Asbestos Thermal Insulating Cement.
- ES-10 Mineral Wool Thermal Insulating Cement.
- ES-11 Expanded or Exfoliated Mica Thermal Insulating Cement.
- ES-12 Diatomaceous Earth Thermal Insulating Cement, for Use from 600 to 1200 F.
- ES-13 Diatomaceous Earth Thermal Insulating Cement, for Use from 1200 to 1900 F.
- ES-14 Blanket Thermal Insulation for Building Purposes.
- ES-15 Blanket Thermal Insulation for Industrial Purposes.
- ES-16 Blanket Thermal Insulation for Refrigeration.
- ES-17 Preformed Pipe Covering Thermal Insulation.
- ES-18 Preformed Block Thermal Insulation.
- ES-19 Structural Board Thermal Insulation.
- ES-20 Malleable Iron Flange, Pipe Fittings, and Valve Parts.
- ES-21 Carbon-Steel and Alloy-Steel Forgings for Magnetic Retaining Rings for Turbine Generators.
- ES-22 Alloy-Steel Forgings for Nonmagnetic Coil Retaining Rings for Turbine Generators.
- ES-23 Carbon-Steel Forgings for Rings for Main Reduction Gears.
- ES-24 Carbon-Steel and Alloy-Steel Forgings for Pinions for Main Reduction Gears.
- ES-25 Carbon-Steel and Alloy-Steel Forgings for Turbine Generator Rotors and Shafts.
- ES-26 Carbon-Steel and Alloy-Steel Forgings for Turbine Rotors and Shafts.
- ES-27 Carbon-Steel and Alloy-Steel Forgings for Turbine Bucket Wheels.
- ES-28 Chloroprene Sheath Compound for Electrical Insulated Cords and Cables.
- ES-29 Special Quality Aluminum Die Castings.
- ES-30 Chloroprene Sheath Compound for Electrical Insulated Cords and Cables when Extreme Abrasion Resistance Is Not Required.
- ES-31 Electrodeposited Coatings of Lead on Steel.

¹ Available in separate pamphlet form.

² Available as "pink slips" affixed to each of the separate respective specifications and published in various issues of the ASTM BULLETIN as indicated by footnotes. Complete set to be furnished with respective parts of the 1942 Book of Standards.

⁵ March, 1942 ASTM BULLETIN.

⁶ May, 1942 ASTM BULLETIN.

⁷ August, 1942 ASTM BULLETIN.

⁸ October, 1942 ASTM BULLETIN.

⁹ December, 1942 ASTM BULLETIN.

¹⁰ January, 1943 ASTM BULLETIN.

¹¹ May, 1943 ASTM BULLETIN.

¹² August, 1943 ASTM BULLETIN.

Emergency Alternate Provisions in Specifications for²

Steel

- EA-A 1 Open-Hearth Carbon-Steel Rails (A 1-39).⁷
- EA-A 21 Carbon-Steel Axles for Cars and Tenders (A 21-39).⁸
- EA-A 25a Wrought Steel Wheels for Electric Railway Service (A 25-41).⁹
- EA-A 26 Steel Tires (A 26-39).⁶
- EA-A 27 Carbon-Steel Castings for Miscellaneous Industrial Uses (A 27-42).⁵
- EA-A 53 Welded and Seamless Steel Pipe (A 53-42).¹⁰
- EA-A 57 Multiple-Wear Wrought Steel Wheels (A 57-39).⁷
- EA-A 67 Steel Tie Plates (A 67-33).⁷
- EA-A 83 Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83-42).⁸
- EA-A 87 Carbon-Steel and Alloy-Steel Castings for Railroads (A 87-42).⁵
- EA-A 120 Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A 120-42).⁸
- EA-A 134 Electric-Fusion-Welded Steel Pipe (Sizes 30 in. and Over) (A 134-42).⁸
- EA-A 135 Electric-Resistance-Welded Steel Pipe (A 135-42).⁸
- EA-A 139a Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not including 30 in.) (A 139-42).¹¹
- EA-A 148a Alloy-Steel Castings for Structural Purposes (A 148-42).¹¹
- EA-A 158 Seamless Alloy-Steel Pipe for Service at Temperatures from 750 to 1100 F. (A 158-42 T).¹²
- EA-A 160 Axle-Steel Bars for Concrete Reinforcement (A 160-39).⁷
- EA-A 161 Seamless Low-Carbon and Carbon-Molybdenum Steel Still Tubes for Refinery Service (A 161-40).⁸
- EA-A 167 Corrosion-Resisting Chromium-Nickel Steel Sheet, Strip, and Plate (A 167-42).⁷
- EA-A 177 High-Strength Corrosion-Resisting Chromium-Nickel Steel Sheet and Strip (A 177-42).⁷
- EA-A 178 Electric-Resistance-Welded Steel and Open-Hearth Iron Boiler Tubes (A 178-40).⁸
- EA-A 179 Seamless Cold-Drawn Low-Carbon Steel Heat-Exchanger and Condenser Tubes (A 179-42).⁸
- EA-A 183 Heat-Treated Carbon- and Alloy-Steel Track Bolts and Nuts (A 183-40 T).⁷
- EA-A 186 One-Wear and Two-Wear Wrought Steel Wheels (A 186-39).⁷
- EA-A 190 Lightweight and Thin-Sectioned Gray-Iron Castings (A 190-40).⁷
- EA-A 192 Seamless Steel Boiler Tubes for High-Pressure Service (A 192-40).⁸
- EA-A 194 Carbon and Alloy-Steel Nuts for Bolts for High-Pressure and High-Temperature Service to 1100 F. (A 194-40).⁸
- EA-A 199 Seamless Cold-Drawn Intermediate Alloy-Steel Heat-Exchanger and Condenser Tubes (A 199-40).⁸
- EA-A 200 Seamless Intermediate Alloy-Steel Still Tubes for Refinery Service (A 200-40).⁸
- EA-A 206 Seamless Carbon-Molybdenum Alloy-Steel Pipe for Service at Temperatures from 750 to 1000 F. (A 206-42 T).¹²
- EA-A 209 Seamless Carbon-Molybdenum Alloy-Steel Boiler and Superheater Tubes (A 209-42).⁸
- EA-A 211 Spiral-Welded Steel or Iron Pipe (A 211-40).⁸
- EA-A 213 Seamless Alloy-Steel Boiler and Superheater Tubes (A 213-42).⁸
- EA-A 214 Electric-Resistance-Welded Steel Heat-Exchanger and Condenser Tubes (A 214-42).⁸
- EA-A 215 Carbon-Steel Castings Suitable for Fusion Welding for Miscellaneous Industrial Uses (A 215-41).⁵
- EA-A 216 Carbon-Steel Castings Suitable for Fusion Welding for Service up to 850 F. (A 216-42 T).⁶
- EA-A 217 Alloy-Steel Castings Suitable for Fusion Welding for Service from 750 to 1100 F. (A 217-42 T).⁶
- EA-A 226 Electric-Resistance-Welded Steel Boiler and Superheater Tubes for High-Pressure Service (A 226-40).⁸
- EA-A 235 Carbon-Steel Forgings for General Industrial Use (A 235-42).¹⁰

- EA-A 236a Carbon-Steel Forgings for Locomotives and Cars (A 236-42).⁸
 EA-A 237 Alloy-Steel Forgings for General Industrial Use (A 237-42).¹⁰
 EA-A 238 Alloy-Steel Forgings for Locomotives and Cars (A 238-42).⁸
 EA-A 240 Corrosion-Resisting, Chromium and Chromium-Nickel Steel Sheet, Strip, and Plate for Fusion-Welded Unfired Pressure Vessels (A 240-42).⁷
 EA-A 241 Hot-Worked High-Carbon Steel Tie Plates (A 241-41).⁷
 EA-A 244 Heat-Treated Wrought Steel Wheels (A 244-42).⁷
 EA-A 249 Atomic-Hydrogen-Arc-Welded and Electric-Resistance-Welded Alloy-Steel Boiler and Superheater Tubes (A 249-42).⁸
 EA-A 250 Electric-Resistance-Welded Carbon-Molybdenum Alloy-Steel Boiler and Superheater Tubes (A 250-41 T).⁸

Non-Ferrous Metals and Alloys

- EA-B 8 Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft (B 8-41).¹⁰
 EA-B 12 Copper Bars for Locomotive Staybolts (B 12-42).¹⁰
 EA-B 19 Cartridge Brass Sheet, Strip, and Disk (B 19-42 T).¹⁰
 EA-B 22 Bronze Castings for Turntables and Movable Bridges and for Bearing and Expansion Plates of Fixed Bridges (B 22-40 T).¹⁰
 EA-B 23a White Metal Bearing Alloys (Known Commercially as "Babbitt Metal") (B 23-26).¹⁰
 EA-B 30 Copper-Base Alloys in Ingot Form for Sand Castings (B 30-42 T).⁷
 EA-B 32a Soft Solder Metal (B 32-40 T).¹⁰
 EA-B 36 Brass Sheet and Strip (B 36-41 T).¹⁰
 EA-B 60 Castings of the Alloy: Copper 88 per cent, Tin 8 per cent, Zinc 4 per cent (B 60-41).⁷
 EA-B 62 Composition Brass or Ounce Metal Castings (B 62-41).⁷
 EA-B 85a Aluminum-Base Alloy Die Castings (B 85-42).¹¹
 EA-B 86a Zinc-Base Alloy Die Castings (B 86-41 T).⁹
 EA-B 100 Rolled Copper-Alloy Bearing and Expansion Plates for Bridge and Other Structural Uses (B 100-40).¹⁰
 EA-B 103 Phosphor Bronze Sheet and Strip (B 103-42).¹⁰
 EA-B 111 Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock (B 111-42).¹⁰
 EA-B 121 Leaded Brass Sheet and Strip (B 121-41).¹⁰
 EA-B 122 Copper-Nickel-Zinc and Copper-Nickel Alloy Sheet and Strip (B 122-39 T).¹⁰
 EA-B 124 Copper-Base Alloy Forging Rods, Bars, and Shapes (B 124-42 T).¹⁰
 EA-B 129 Cartridge Brass Cartridge Case Cups (B 129-40 T).¹⁰
 EA-B 130 Gilding Metal Sheet and Strip (B 130-41 T).¹⁰
 EA-B 131 Gilding Metal Bullet Jacket Cups (B 131-40 T).¹⁰
 EA-B 133 Copper Rods, Bars, and Shapes (B 133-42 T).¹⁰

- EA-B 134 Brass Wire (B 134-42 T).¹⁰
 EA-B 135 Miscellaneous Brass Tubes (B 135-42 T).¹⁰
 EA-B 139 Phosphor Bronze Rods, Bars, and Shapes (B 139-42 T).¹⁰
 EA-B 143 Tin-Bronze and Leaded Tin-Bronze Sand Castings (B 143-42 T).⁷
 EA-B 144 High-Leaded Tin-Bronze Sand Castings (B 144-42 T).⁷
 EA-B 145 Leaded Red Brass and Leaded Semi Red Brass Sand Castings (B 145-42 T).⁷
 EA-B 146 Leaded Yellow Brass Sand Castings for General Purposes (B 146-42 T).⁷
 EA-B 148a Aluminum-Bronze Sand Castings (B 148-42 T).¹⁰
 EA-B 151 Copper-Nickel-Zinc Alloy Rod and Wire (B 151-42 T).¹⁰
 EA-B 152 Copper Sheet, Strip, and Plate (B 152-41 T).¹⁰
 EA-B 159 Phosphor Bronze Wire (B 159-42 T).¹⁰
 EA-B 169 Aluminum Bronze Sheet and Strip (B 169-41 T).¹⁰
 EA-B 171 Copper-Alloy Condenser Tube Plates (B 171-42 T).¹⁰

"C" and "D" Groups

- EA-C 150 Portland Cement (C 150-42).¹
 EA-D 27a Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound (D 27-41).⁶
 EA-D 69a Friction Tape for General Use for Electrical Purposes (D 69-38).¹²
 EA-D 119 Rubber Insulating Tape (D 119-38).¹⁰
 EA-D 224 Asphalt Roofing Surfaced with Powdered Tale or Mica (D 224-41 T).⁷
 EA-D 249 Asphalt Roofing Surfaced with Coarse Mineral Granules (D 249-42 T).⁷
 EA-D 353 Insulated Wire and Cable: Performance Rubber Compound (D 353-41).⁶
 EA-D 375 Test for Asbestos Roving for Electrical Purposes (D 375-42). (Specifications and Methods)⁷
 EA-D 455 Milled Toilet Soap (D 455-39).⁶
 EA-D 469a Insulated Wire and Cable: Heat-Resisting Rubber Compound (D 469-41).¹⁰
 EA-D 499 White Floating Toilet Soap (D 499-39).⁶
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